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THE FAUNA OF A SMALL STREAM AT LE TRAYAS, VAR, FRANCE, IN JULY—AUGUST, 1932

By Drs. O. W. and M. J. Richards, FF.R.E.S.

The hills which so closely abut on the sea in the Esterel are cut into a number of deep valleys. The streams at the bottom of these usually dry up in the summer, but, as in the one specially studied, a small trickle, connecting pools up to two feet deep, may be left in the lower part. The pools are in basins in the rock; their water is warm and often impregnated with organic matter; there is no macroscopic plant-life. The fauna is interesting for two reasons. First, that in the winter rains the streams must be powerful torrents (the carved rocks show this), but in the summer the animals must adapt themselves to extremely different conditions. Secondly, with the recession of the water, there appears to be a considerable concentration of the fauna; observations on the Hemiptera suggest that competition for food may become very keen.

The extensive Hymenopterous fauna, chiefly Sphecoids and Vespoids coming to drink, is not dealt with; no Lepidoptera were seen drinking.

Mollusca.

Ancylus lacustris (L.) was common, adhering to the rocks.

Thysanura.

An undetermined Machilid was abundant running over the very hot rocks at the edges of the stream.

Ephemeroptera.

(Adults determined by Mr. D. E. Kimmins.) *Habrophlebia fusca* Curt., adults not uncommon; *Leptophlebia* sp., nymphs common; *Ecdyurus* sp., *Caenis* sp., one nymph of each.

Odonata.

(Adults determined by Mr. D. E. Kimmins.) Adults were abundant in the valley, but the nymphs in the stream belonged to other species. The following adults were common :—*Aeshna mixta* Latr., *Sympetrum meridionale* Sélys, *Orthetrum coerulescens* Fab., *Lestes viridis* Van der Lind., *Calopteryx haemorrhoidalis* Van der Lind., *Pyrrhosoma tenellum* Vill.

Two types of nymphs were found :—*Boyeria irene* Sélys (1 specimen) and Agrionid sp. (common). The last named is an anomalous form, the general features being those of an Agrionid but the caudal gills resembling those of *Calopteryx.*

Plecoptera.

Leuctra sp., nymphs rare.

Hemiptera.

Gerrididae. *Gerris gibbifer* Schum., common.

Hydrometridae. *Hydrometra stagnorum* L., common.

Nepidae. *Nepa cinerea* L., common, but mainly in the nymphal stage.

Notonectidae. *Notonecta maculata* Fab., abundant; no other species was found here, though *N. furcata* Fab. occurred in larger streams in the same district. It is probably significant that *N. maculata* lays its eggs on rocks, etc., whereas the other species insert them in plants.

Corixidae. *Corixa transversa* Fieb. (det. Mr. W. E. China), not common.

Trichoptera.

Stenophylax sp., larval cases not very common.

Stactobia furcata Mosely (det. Mr. M. E. Mosely), adults not uncommon, hopping about on the rocks at the edge of the water.

Diptera.

CHIRONOMIDAE. Larvae common.

LEPTIDIDAE. One larva of *Atherix* sp.

TABANIDAE. A number of species were found in the vicinity and probably bred in the pools. *Tabanus apricus* Mg. was particularly common and females and males were seen dipping in the pools. One male of *Dasystipia rustica* L. was also seen dipping. It was found that to hold these insects for twenty-five seconds one foot beneath the surface of the sea does them no injury.

DOLICHOPODIDAE (det. by M. l'Abbé Parent). Flies of this family were very common on the edge of the stream; most of the species are predacious. The following were obtained :—*Tachytrechus notatus* Stann., common; *T. insignis* Stann., 1 ♀; *Hercostomus chetifer* Walk., common; *Ludovicus eucerus* Lw., 1 ♂; *Acropsilus niger* Lw., ♂♂ common.

Muscoidea.

Two predatory species *Lispe tentaculata* Deg. (ANTHOMYIDAE) and *Octhera mantispa* Lw. (EPHYDRIDAE) were common on the edge of the stream. *Prosopomyia pallida* Lw. (LAUXANIIDAE) was common with them, but its connection with water is more problematical.

Coleoptera.

DYTISCIDAE (det. Mrs. J. Omer-Cooper). *Meladema coriacea* Cast., 2 specimens; *Agabus didymus* Ol., *A. bipustulatus* L. and *A. brunneus* Fab., 1 specimen of each; *Graptodytes lepidus* Ol., 4 specimens; *G. varius* Aubé., 5 specimens; *Bidessus minutissimus* Germ., 2 specimens; *Deronectes moestus* Fairm., 5 specimens.

GYRINIDAE (det. by Mr. J. Omer-Cooper). *Gyrinus caspius* Men., a few specimens.

DRYOPIDAE. *Dryops auriculatus* Geoffr., common in moss in the more rapid parts

ELMIDAE. *Latelmis opaca* Müll. (det. Dr. K. G. Blair), rare; with the preceding.

Hymenoptera.

FORMICIDAE. Ants, especially *Camponotus cruentatus* Latr. and *Cremastogaster scutellaris* Ol., were common on the rocks at the edge of the stream. They formed a certain part of the food of the aquatic Hemiptera.

It was noted that the density of the smaller DYTISCIDAE and of the aquatic Hemiptera was higher than usual. One small pool (about 3 × 2 feet, 1½ feet deep) contained more than 15 *Notonecta*, two of the large *Meladema* and numerous *Gerris*. Ants or Machilids thrown into the water were eagerly pounced on by the *Gerris*, but the *Notonecta* also came up from below. In two cases *Notonecta* was seen to take prey away from *Gerris* and carry it beneath the surface. We formed a strong impression that *Gerris* was completely overawed by *Notonecta*.

We are much indebted to the various experts whose names are mentioned in the text for the identification of species.

HISTOLOGICAL OBSERVATIONS ON A NON-MOULTING STRAIN OF SILKWORM

By Tadao Yokoyama.

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Communicated by Dr. V. B. Wigglesworth, F.R.E.S.

Introduction.

Umeya (1930) reported on the genetical characteristics of an abnormal strain of silkworm which differs from the normal as follows :—

(1) Abnormal larvae do not grow beyond the size of the 4th or the 5th day larvae though they seem to take abundant food. At about the 13th day, when the normal larvae from the same batch begin to enter the 3rd moult, they all die.

(2) Among the abnormal larvae there are a few which moult and follow the normal course of development, though somewhat later than the normal.

(3) This abnormality is inherited. From the crosses between the normal larvae from the same batch as the abnormal, 4 batches out of 10 of the next generation segregate abnormal larvae, and within such a batch, the ratio of abnormal larvae to normal is about 4 : 1.

The most conspicuous characteristic of the abnormal larvae is that they do not moult. As there are many conflicting theories, or rather hypotheses, concerning the physiological basis of moulting in insects, these abnormal larvae should make an interesting study.

Dr. Umeya gave me some eggs of this strain in 1932, and I have been able to discover some features which are recorded here.

I. General Description of the Abnormality.

1. *When can the abnormal larvae be distinguished for the first time?*

Up to the 2nd day of the 1st stage, I cannot distinguish the abnormal larvae either in their size, form or colour. On the 3rd day in normal larvae from the same parent as the abnormal ones, the thorax is white and the abdomen is brown, while the abnormal larvae are the same dark colour as on the preceding day and in size are slightly larger than the " ant " stage but far smaller than normal larvae.

At this stage there can usually be found larvae intermediate between normal and abnormal. These are inferior in size, but similar in colour to normal ones (fig. 2).

On the 5th day the normal larvae begin to moult, but the abnormal ones do not moult and the colour of their skin becomes translucent just like that of the " oily " race.

2. *Duration of life of abnormal larvae.*

The death rate of the abnormal larvae increases rapidly after the 9th day when the normal ones begin to enter the 2nd moult, and remains high until about the 14th day, when they all die. At this time the normal larvae are beginning the 3rd moult (fig. 1).

3. *Body-weight of abnormal larvae.*

Method: Until the 4th day of the 1st stage the normal and abnormal larvae were weighed together. After that I divided them into 3 lots of 200–300 larvae, abnormal, intermediate and normal respectively. Fifty larvae from each lot were weighed once every day and the results are shown in fig. 2.

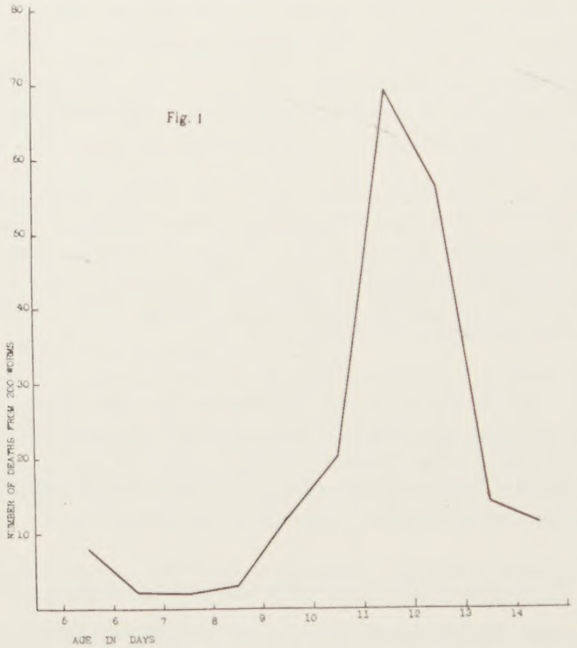

FIG. 1.—The number of deaths in abnormal larvae; the ordinate represents the number of deaths in 200 larvae and abscissa represents age in days.

The abnormal larvae increase in weight and size very slightly. One very interesting phenomenon, however, is that the change in body-weight in the abnormal larvae seems to correspond to the moulting period of the normal ones, though it is a very slight change and takes place two days after normal. The change of body-weight in the intermediate larvae is just the same as in the normal ones but occurs one day later.

II. HISTOLOGICAL OBSERVATIONS.

Method: The material was fixed in Carnoy's fluid and imbedded in paraffin. Sagittal sections 8 μ in thickness were made and stained in haematoxylin and eosin. The number of mitoses was counted in 5 successive sections about the median line of the body and reduced to the number per section. Total number of the hypodermal cells in 1 section is 500–700 and that of fat cells about 300. The curve based on the percentage of the dividing cells to the total cells shows practically the same form as that based on the number of mitoses per section. Glycogen was examined by the iodine method.

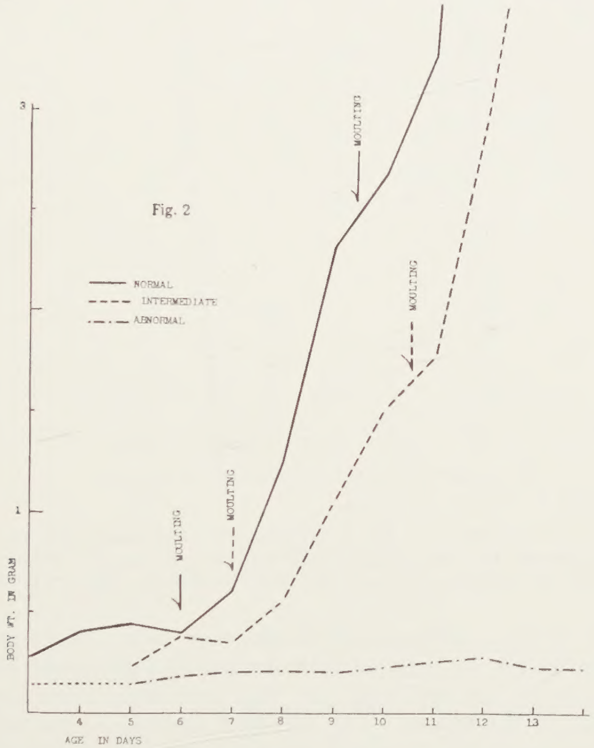

FIG. 2.—Growth in body-weight of abnormal, intermediate and normal larvae. The ordinate represents the body-weight of 100 larvae in grams and the abscissa represents age in days.

1. *Cell division in the hypodermal cells.*

In the preparations made as explained above, I cannot observe any difference in the structure of the hypodermis of the abnormal ones from that of the normal until the 2nd day of the 1st stage. The number of mitoses, however, differs much between the two when the normal ones begin to moult. Fig. 3 shows the daily change in the number of hypodermal mitoses of abnormal and normal larvae.

The mitoses of normal larvae begin to appear on the 3rd day and reach a maximum on the 5th day. After that they decrease suddenly, reaching zero on the 6th day just before ecdysis occurs, and take practically the same course at the 2nd moult. It is interesting to note that in the abnormal larvae there is a change in the number of mitoses, though in somewhat decreased degree and about one day late, compared with that of the normal.

2. *Cell division in the adipose tissue.*

The adipose tissue also undergoes a distinct change during moulting. The change in the number of mitoses in the fat cells shown by the method mentioned above is represented in fig. 4.

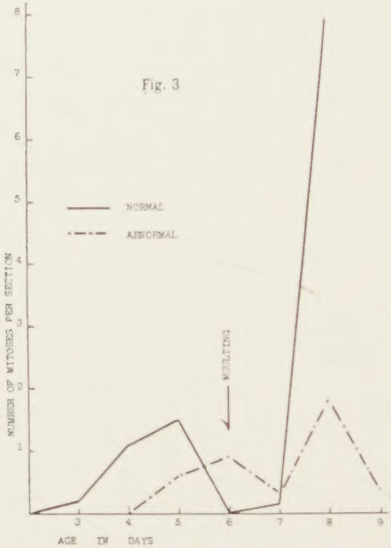

FIG. 3.—The number of mitoses in the hypodermis of abnormal and normal larvae. The ordinate represents the mean number of mitoses per sagittal section based on the observation of 5 successive sections, and the abscissa represents age in days.

Here, also, the same phenomenon is observed as in the hypodermis, *i.e.* a periodic change in the fat cells of both normal and abnormal larvae, but the second maximum in the former is very high and there is no sign of decrease until the death of the larvae. The glycogen content of the fat cells of the abnormal larvae also shows changes of the same type as in normal ones. That is, it shows maxima corresponding to the moults, but the absolute amount of this substance is much less than normal.

3. *Corpora allata.*

According to the recent work of Wigglesworth (1934) it has been suggested that the *corpora allata* play an important rôle in the ecdysis of *Rhodnius prolixus*.

In my abnormal larvae the *corpora allata* do not differ from those of the normal ones except in size, where there is a slight difference after the 4th day of the 1st stage (abnormal 21·4 μ normal 27·4 μ on the 4th day; 28·0 μ and 35·0 μ on the 6th day). As there is little cytoplasm in the cells of the *corpora allata* of normal and abnormal larvae and no periodic change can be detected, I agree with Ito (1918) that the *corpora allata* are not active in the larval stage of the silkworm.

4. *Exuvial glands.*

No difference can be detected in these glands until the 2nd day of the 1st stage, after which the gland in the normal larva grows suddenly but that of the abnormal one does not.

5. *Malpighian tubes.*

The Malpighian tubes of the abnormal larva cannot be distinguished from normal at the beginning, but they contain an unusually large quantity of glycogen just before death.

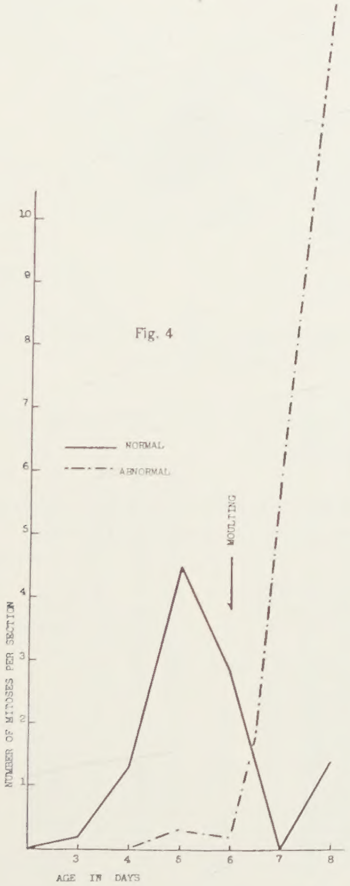

FIG. 4.—The number of mitoses in the fat cells expressed by the same method as fig. 3.

6. *Oenocytes.*

The oenocyte, and here I allude only to the larval oenocyte (Verson, 1892, 1900, 1911), is sometimes considered to be an organ directly related to moulting (Verson, 1900; Koller, 1929). The abnormal larva differs from normal particularly in the behaviour of this cell.

On the 1st day of the 1st stage all the oenocytes assume a spherical, or ellipsoid, shape and their cytoplasm is homogeneous, only rarely containing small vacuoles. The nucleus is spherical with its chromatin granules evenly distributed along the nuclear membrane, and containing sometimes one or two basophile nucleoli.

On the 2nd day may be distinguished two kinds of oenocytes; the 1st type is almost the same in appearance as on the preceding day, except for a slight increase in the number of vacuoles. In the 2nd type the cytoplasm contains many conspicuous vacuoles and the chromatin of the nucleus becomes a compact mass showing no detail and leaving a space between the mass and the nuclear membrane (fig. 5 A, B).

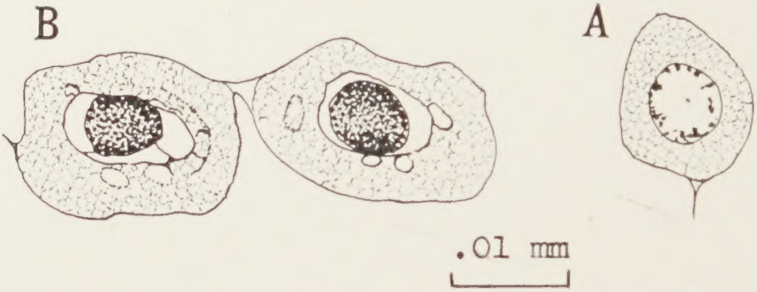

Fig. 5.—Oenocytes of abnormal (A) and the normal (B) larvae on the 3rd day of the 1st stage.

The ratio of the number of the 1st type to the 2nd, changes according to the individual (table 1 and fig. 6).

Table 1. The body-length in relation to ratio between 3 types of oenocytes in the 2nd-day larvae from the abnormal strain.

Individuals.	Body-length (mm.).	Ratio between oenocytes of			Individuals.	Body-length (mm.).	Ratio between oenocytes of		
		1st.	Interm.	2nd.			1st.	Interm.	2nd.
1	2·57	18	17	65	19	3·47	13	22	65
2	2·81	93	2	5	20	3·48	10	26	64
3	2·82	73	11	16	21	3·51	90	6	4
4	3·00	9	21	70	22	3·53	70	20	10
5	3·04	85	14	1	23	3·55	35	26	39
6	3·09	83	5	12	24	3·56	41	30	38
7	3·13	80	9	11	25	3·56	36	31	33
8	3·21	7	14	79	26	3·59	69	19	12
9	3·27	36	17	47	27	3·60	77	16	7
10	3·27	76	16	8	28	3·66	19	16	65
11	3·32	93	5	2	29	3·70	96	3	1
12	3·33	36	31	33	30	3·74	33	27	40
13	3·34	51	21	28	31	3·77	17	33	50
14	3·37	58	16	26	32	—	28	3	69
15	3·38	91	3	6	33	—	49	4	47
16	3·44	8	17	75	34	—	91	0	9
17	3·45	75	18	7	35	—	73	0	27
18	3·47	25	28	47					

As the cells of the 2nd type are rarely observed in abnormal larvae after the 3rd day (table 2), and it is inconceivable that the cells of the 2nd type on the 2nd day change into the 1st type on the following day, abnormal larvae are probably those which assume the features of the larvae with a high percentage of the 1st type of oenocyte. Thus one can, with a high degree of probability, distinguish the abnormal larvae on the 2nd day by the structure of the oenocytes.

TABLE 2. The ratio between the oenocytes of 3 types in relation to development.

	Not differentiated.			Abnormal.			Normal.		
	1st.	Interm.	2nd.	1st.	Interm.	2nd.	1st.	Interm.	2nd.
1st day	99	0	1						
2nd ,,	59	2	39						
3rd ,,				99	1	0	2	3	95
4th ,,				96	3	1	0	1	99
5th ,,				100	0	0	0	3	97
6th ,,				100	0	0	5	2	93
7th ,,				99	1	0	0	0	100
8th ,,				99	1	0	0	0	100

Fig. 6

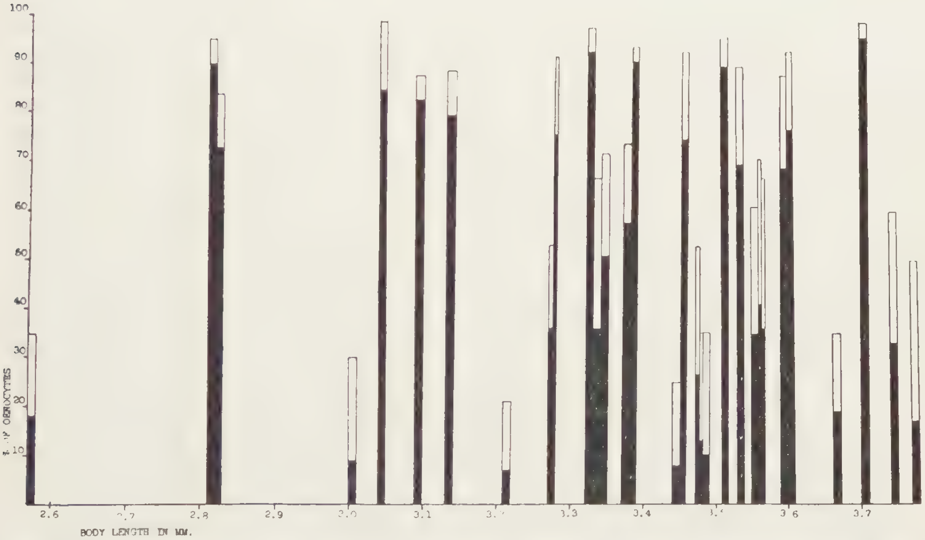

FIG. 6.—The relation of body-length to the ratio between 3 types of oenocytes in 2nd day larvae from the abnormal strain. Each column represents 1 larva. The ordinate represents percentage of the 1st (black area) and the intermediate (white area) oenocytes and the abscissa represents body-length in mm.

I have examined 35 larvae on the 2nd day of the 1st stage, 6 of which showed over 90% of the 1st type. It is not certain that the batch which I selected to examine would segregate abnormal ones, or that the 6 larvae mentioned above were abnormal, but the ratio 35 : 6 is very near to 4 : 1 which is the average ratio of normal to abnormal larvae in one batch reported by Umeya (1930). If it be assumed that the 6 larvae mentioned above were abnormal, and this seems to me a very probable assumption, there is no correlation between the high percentage of the 1st type of oenocyte and the body size (fig. 6). This fact shows that the oenocyte is probably the first organ by which the abnormal larvae may be distinguished from normal.

From the 3rd day of the 1st stage to the 9th day, *i.e.* just before death, the oenocytes of the abnormal larvae grow from 10–16 μ to 23–26 μ in diameter. Their cytoplasm is nearly always homogeneous and only rarely contains small vacuoles which disappear about the 5th–6th day and reappear after the 7th day, but they never have such conspicuous vacuoles as the oenocytes of the 2nd type. Their nuclei begin to show a slight increase in the amount of chromatin from the 5th day onward, especially after the 7th day, but they never form a compact chromatin mass nor an intranuclear space. In short, the oenocytes in the abnormal larvae seem to be comparatively inactive. Another fact which shows their inactivity is the absence of glycogen in the cytoplasm.

Almost all the oenocytes of the normal larvae belong to the 2nd type after the 3rd day of the 1st stage (table 2), and grow from 14–19 μ to *ca.* 30 μ in the same interval of time as the abnormal ones, *i.e.* from the 3rd day of the 1st stage to the 4th day of the 2nd stage. Their cytoplasm and nuclei undergo a certain sequence of changes corresponding to each moult as reported by Verson (1900). As Verson's description, however, does not show the relation of the changes in the cell to each period of moulting time, I will describe it here.

On the 2nd day of the 1st stage, the chromatin granules begin to form a chromatin mass, and in the cytoplasm distinct vacuoles appear, as mentioned before. Such processes become most intense on the 4th day. As the larva enters its moulting period on the 5th day, the chromatin mass stains less strongly and one can observe chromatin granules scattered in it, while the vacuoles in the cytoplasm decrease greatly especially in the periphery of the cell. In the larvae which have finished ecdysis, the chromatin mass stains still more weakly and shows one or two basophile nucleoli. The cytoplasm also becomes much reduced in volume and does not contain any vacuoles except those which are sometimes observed in the central part.

On the 2nd day of the 2nd stage the nucleus again makes a compact mass and the cytoplasm begins to show vacuoles which will increase more and more in size and number. On the 4th day the larva enters the 2nd moulting period, and its oenocytes undergo almost the same course of changes as in the 1st moult.

III. DISCUSSION.

The facts recorded in the present paper have two special points of interest.

1. *Imperfect moulting.*

Here is seen a kind of moult in which the insect does not go so far as ecdysis, but shows the changes in several tissues which are characteristic of moulting. In the moulting of insects many physiological processes are involved which reveal themselves in a certain order in normal larvae. In abnormal larvae, however, owing to some physiological defect or defects, some tissues (hypodermis, fat cells) show changes like those normal to moulting, others do not, thus preventing actual ecdysis. The cause of this failure may be sought either in weakness of rhythmical change in those tissues which show it, or in the absence of some essential factor. Which of the above alternatives is the real one must be tested experimentally in the future, but the existence of such an imperfect moulting is an established fact. According to Przibram (1931) the number of moults in Lepidoptera is considered to have diminished in the course of phylogeny. Imperfect moulting seems to be interesting from this point of view.

2. *Site of secretion of moulting hormone.*

It seems probable that some kind of hormone plays an essential rôle in causing moulting in insects, as stated by v. Buddenbrock, Koller, Schulze, Verson and Wigglesworth, but neither the site of secretion nor the function of the hormone has ever been directly proved. In his elaborate work Wigglesworth (1934) proved that the head is essential for the moulting of *Rhodnius prolixus*, but whether the *corpus allatum*, as he suggests, secretes such a hormone or not is a question to be decided by future experiments. In the silkworm the *corpora allata* show no sign of rhythmical activity in the larval stage; as Ito (1918) records, they appear to have no important relation to larval moulting in this species.

v. Buddenbrock enumerated the necessary characteristics for the incretory organ of the moulting hormone, among these are: (1) rhythmic activity corresponding to moulting; (2) it must not be preceded in activity by any other organ influenced by the hormone in question. According to him a large secreting cell in the Verson's gland fulfils all the conditions, and must be the organ which introduces and regulates the process of moulting, but, as he himself acknowledges, Verson's gland does not precede in activity all the other organs; its most active phase falling at the end of the moulting period. It is true that Verson's gland has some direct relation to moulting but probably not that suggested by v. Buddenbrock.

Besides the secretion of moulting hormone many functions are attributed to the oenocyte: respiration, Landois (1865); excretion, Koschevnikov (1900); and metabolism, Kremer (1925) and Stendell (1912).

The probable relation of the oenocyte to moulting is suggested by Verson (1900) who investigated the rhythmical activity of that cell, and his opinion is partly adopted by Koller (1929). Wigglesworth (1933) thinks that oenocytes in *Rhodnius* are concerned in the formation of new cuticle, because (1) they are too numerous to be considered as incretory organs and (2) they undergo periodic change during moulting.

The purpose of the present paper is to discover the histological difference between the abnormal and normal silkworm larva, and this is most clearly revealed in the features of the oenocytes. I cannot ascertain whether the abnormality in the oenocytes is the direct cause of non-moulting or whether it first inhibits growth, possibly through metabolism, and then causes non-moulting; or whether the abnormality in the oenocytes and non-moulting are two results of a still unknown cause; but it seems to me worth recording the following two facts: (1) in abnormal larvae the first sign of abnormality to be observed is in the activity of the oenocytes and (2) in normal larvae oenocytes show a rhythmical activity preceding other organs at each moult.

IV. SUMMARY.

1. Comparisons are made of the body-weight, hypodermis, fat cells, *corpora allata* and oenocytes, etc., in normal and abnormal silkworms. The latter die, after living 13–15 days from hatching, without growing beyond the size of 4th or 5th day larvae. They feed normally, at least at the beginning, but fail to moult.

2. In abnormal larvae there are rhythmical changes in the number of mitoses in the hypodermis and fat cells corresponding to the moult of normal larvae. The 2nd maximum of the mitoses in the fat cells is very high and shows no sign of decrease up to the time of death.

3. In normal larvae, oenocytes begin to be active on the 2nd day of the 1st stage, but in abnormal ones they do not show such signs up to the time of death. On the 2nd day there is no difference observable in organs other than oenocytes.

ACKNOWLEDGMENTS.

My best thanks are due to Dr. Y. Umeya, who gave me a supply of the abnormal strain of silkworm which is the main material for the present research. I thank Prof. P. A. Buxton and Dr. V. B. Wigglesworth of the London School of Hygiene and Tropical Medicine, where most of the present work has been carried out, for affording me all facilities and advice in the course of this work. I must also acknowledge the kind help of Dr. Violet Grubb of Westfield College in preparing the manuscript.

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THE IDENTITY OF DRAGONFLIES OFFERED TO HER YOUNG BY A PIED WAGTAIL, ON THE CAM

By Sir EDWARD POULTON.

I WISH to record at the earliest opportunity the following correction kindly sent to me by Mr. John Cowley :—

"1936, *Jan.* 2.—I have just seen your note to Mrs. Brindley's remarks on a Pied Wagtail feeding her brood on dragonflies (*Proc. R. ent. Soc. Lond.*, **10** : 65). You there suggest that the dragonfly was *Calopteryx virgo* ; but I have never found this species on any part of the Cam, or anywhere else in Cambridgeshire, and I do not think that it has ever been recorded from the county (though probably present in suitable localities—the Cam is not the type of habitat for *virgo*). *Agrion* (*Calopteryx*) *splendens* occurs here and there on the Cam: but I would suggest that Mrs. Brindley's 'slender blue dragonfly' is more likely to be a Coenagriid, very possibly *Enallagma cyathigerum* Charp., which is very common on many parts of the river."

EMERGENCE OF THE SEXES FROM COCOONS OF THE BEE *OSMIA AURULENTA* PANZ. NESTING IN SNAIL-SHELLS AT WALLASEY

By Dr. G. ARNOLD, D.Sc., A.R.C.Sc.

[Communicated by Sir EDWARD POULTON, who suggested that the diminishing size of the spiral may have prevented the storing up of sufficient food for female larvae and have acted as the stimulus under which male-producing (unfertilised) eggs were laid and the appropriate amount of nutriment provided.]

1936, *Jan.* 9.—Herewith I return the proof of de Meillon's paper. Although it is very many years ago now since they were made, the following observations which I made on *Osmia aurulenta* nesting in snail-shells, collected at Wallasey, may be of interest to you.

I collected quite a number of shells which were occupied by *Osmia* larvae. In some cases I carefully noted the emergence of the bees after having chipped little pieces out of the shell, so as to show the greater part of each cocoon intact. In other instances, I left the shells entire, but noted the sexes of each specimen as it emerged. In both I distinctly remember that the sex of the specimen at the thin end of the shell was male, and sometimes also the one next to it, and the others at the wide end of the shell were females. I was able in some instances, where the shell had been chipped to expose the side of the cocoon, to establish the fact that the occupant of the inmost cocoon had reached the imago stage, by hearing the buzzing of the insect when the side of the cocoon was slightly pressed. However, in none of these cases did the males attempt to force their way to the open by penetrating through the cocoons in front of them. They waited till the one in front had departed.

As the cells at the thin end of the shell are smaller, it is probable that the amount of food stored in them by the mother-bee is less than in the outer cells and one would therefore expect the occupants to take less time to mature, but nevertheless they come out last, at least according to my observations. There may be a reason for this. The sisters will have flown away and will have copulated with males from other shells by the time their brothers are able to emerge.

CAPTURE OF THE LARGE *PAPILIO (ILIADES) POLYMNESTOR PARINDA* MOORE, BY A PARADISE FLYCATCHER—*TCHITREA PARADISI PARADISI* L., IN CEYLON

By W. E. Wait.

(*Late Ceylon Civil Service.*)

[Communicated by Sir Edward Poulton, who remarked on the great interest of the capture by the bird of such a large butterfly as the "Fluted Swallowtail" *P.* (*I.*) *polymnestor parinda*, and said that the observation would be also referred to in Prof. Hale Carpenter's paper to appear in the April No. of *Science Progress*.]

In my early days in Ceylon, before I had taken up the study of ornithology with any seriousness, I was stationed as a cadet at Anuradhapura, the well-known capital of the North Central Province. Just outside the Cadets' Bungalow stood a large spreading Ingasaman—the Peruvian Rain tree—which shaded one corner of the verandah. This tree was a favourite haunt of a pair of Paradise Flycatchers which, as is usual with this species, used to perch and nest among the low branches well inside the tree and not on the circumference.

One Sunday morning I was lounging in my long-chair on the verandah when my attention was attracted by a fine specimen of the great blue and black Papilio—*Iliades polymnestor parinda*—flapping slowly past between me and the trunk of the tree. This is one of the two largest butterflies in Ceylon; the wings are broad and the wing-area cannot be much less than that of an average flycatcher.

As it drifted past the usual perch of the Paradise Flycatchers one of them darted out sideways to the flight of the insect, and as the butterfly's wings met at the end of the upward stroke, neatly nipped them together and so prevented them from flapping.

My impression was that the nipping was done with the feet, but the bird's action was so sudden that, before my attention could be focussed on detail, it had carried its booty back to the branch, where it stood on the insect and pecked at the juicy body. The capture, too, was made in the shade of the tree. I could only note that the swoop had been made at the end of the butterfly's up-stroke and that, as the bird flew directly away from me, the butterfly was dangling helpless and unable to use its folded wings.

During the whole of my thirty years in Ceylon I never again saw this flycatcher, or any other bird, tackle such a large butterfly and so cannot say whether the capture was a sudden brain wave when the bird saw the butterfly so close, or whether the species does occasionally use this abnormal method to capture very large butterflies. But the neatness and manner of the feat were extraordinary. If only one wing or the body had been caught, the flapping of both, or only one of the large free wings would have made the butterfly far too unmanageable for a successful capture.

I regret that I cannot give the incident a definite date. As I said, it took place before I began to study birds seriously or to take notes; but it happened when I had been at Anuradhapura some time. As I went there in Dec. 1902 and left in Feb. 1905, it was probably some time in 1904 that it occurred.—W.E.W. : 2.xii.1935.

A PEBBLE-LIKE ACRIDID WHICH, WHEN THREATENED, ASSUMES A SCORPION-LIKE APPEARANCE: THE "STONE-DESERT," NORTH OF THE BISKRA OASIS

By H. M. Wallis.

[Communicated by Sir Edward Poulton, who said that he hoped that entomologists would soon visit this "Stone-Desert," collect specimens and carefully observe the details of the insect's behaviour. The resemblance of allied forms to stones had been recorded by W. J. Burchell in 1822, *Travels in the Interior of Southern Africa*, **1** : 310, 311. Dr. B. P. Uvarov had kindly suggested that Mr. Wallis's insects may have been nymphs of *Eremocharis insignis* Lucas, an Acridid not uncommon in the stony deserts of North Africa.]

Very few people, I think, ever visit the narrow strip of "Stone-Desert" (so-called in distinction to "Les Sablons"—the Sand-Desert, south of the Biskra Oasis). Why should they? Its flora is *very* sparse, small and prickly. It has (I saw) at least one *Noctua*—long-winged and sand-coloured; one or two birds—a *Caprimulgus* and, I expect, two Wheatears. It has one land-snail (*Otala lactea* Müller *) and a woolly-leaved shrub it feeds on. I sent live shells to Cromwell Road [British Museum (Nat. Hist.)]. It has a line of low stony bluffs constantly breaking away into steep "nullahs" of sliding rounded pebbles (the beach of a dried-up sea), and it is along the levels of these pebbles that, as one walks, a stone "jumps" from one's foot at times and so deceptively that I thought at first *I* had impelled it, until I saw one *fall on its back and right itself*. Then I watched and found these "stones" had each a pair of very small and short movable antennae. (Legs, large and small, I discovered later.) The "stones" varied widely in size and tint but all were of the same shape, viz. a rubbed-down square. The marked "thighs" are very much withdrawn and inconspicuous.

When I followed the leap of a largish "stone" and put my hand to it (or above it), it instantly turned into a "scorpion," cocked-up its hinder end, loosened a pair of rather boldly barred thighs and entwined the "tarsi" and bent them over its back and agitated them! The "tail" seemed impossibly long, and absurdly tremulous to me at the time. The insect simultaneously extended two short legs (imperfectly observed), one on each side of its "face," suggesting "jaws," or whatever you might call them. In fact, from being a "stone" among hundreds and thousands of rubbed-down pebbles, it made itself as conspicuous and as menacing as it knew how. I had no killing-bottle. I confess I should have collected at least a dozen: I didn't, and regret the omission.

Is it not worth your while to get someone known to you who may be wintering in Algeria to look this creature up? Observe, I don't think it had wings. I can only suppose it was a larva of some grasshopper, for it varied widely in size. All its upper surface seemed protectively coloured, ruddy, sandy, or khaki-tinted (each was whole-coloured); only the transversely barred thighs gave it away. The right time of year would be *before* the middle of April—say late February and/or March, when the first green things are flowering and ere the heat begins.

* Kindly determined by Mr. G. C. Robson.

THE LUMINOUS SECRETION OF THE CENTIPEDE *GEOPHILUS ELECTRICUS* (L.) AS A DEFENCE AGAINST THE ATTACK OF BEETLES, ETC.

By H. N. Ridley, F.R.S.

[Communicated by Sir Edward Poulton, who commented on the interesting confirmation of Kirby and Spence by Mr. Ridley's observations.]

I was visiting ivy blossoms about 9.0–10.0 p.m. in September, about 1874, at Cobham, Kent, when I noticed a light under some laurels in the garden, and saw it was a *Harpalus ruficornis* Fab., running round a *Geophilus electricus* which was shining brightly. The beetle seized the centipede in its mandibles and shook it just as a terrier does a rat, but from time to time dropped it and ran round and round it. The beetle's mouth, face and legs were covered with patches of luminous matter which seemed to annoy it. When I brought my lantern nearer to the combatants the beetle ran off and I picked up the centipede quite unhurt; and examining it a few minutes later found it was no longer luminous, nor could I afterwards make it show its light. I often found this centipede on sugar and decayed fruit, and even if one touched it with a piece of stick it would not show its light, but only did so when trodden on or otherwise injured. In my MS. note on this subject I find I wrote that Kirby records a similar fray between a beetle and centipede.* I noticed that when one breathed on the luminous matter it became brighter.

We had a similar electric centipede in Singapore, which was often to be found among one's papers, and which the natives all affirmed (quite erroneously) was a very deadly beast. I encouraged it, as it apparently fed on Psoci, and I think Lepismas which nibbled the papers. One once gave me quite a start. When I got into bed one night I discovered a blue glow on the sheet and thought the bed was on fire, so sprang out quickly and discovered it was only an electric centipede I had rolled over on, which had exuded its luminous matter on the sheet. These animals seem only to exude the luminous matter when hurt, and apparently use it for defence only.

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* *Introduction to Entomology*, Kirby and Spence, People's Edn., Lond., 1867, p. 409, Letter XXI: "Means by which insects defend themselves." "Mr. Sheppard once noticed a *Carabus* running round the last-mentioned insect [*Geophilus electricus*], when shining, as if wishing, but afraid to attack it."

Book Notice.

K. C. McKeown. *Insect Wonders of Australia.* Pp. xii + 252, 16 pls. 8vo. Sydney, 1935. Angus & Robertson Ltd., 6*s.* 0*d.*

This little book gives a considerable amount of information not readily obtainable elsewhere, particularly in the chapter on "Insect foods of the Australian aborigines."

The illustrations are noteworthy for the excellence of the reproduction and the fact that they are, in the main, original photographs taken from life.

It should be pointed out that in the publisher's notice a "frontispiece in colour" is mentioned. In fact this picture appears only on the dust-wrapper, which is the more regrettable since it was apparently specially drawn for the book.

This book should be of value in providing non-specialists in Australia with a reliable account of the subject with which it deals.

ECCOPTOPTERA CUPRICOLLIS CHD., AND ANOTHER COLEOPTEROUS MUTILLOID

By Professor G. D. Hale Carpenter, F.R.E.S.

Mr. E. Burtt, of the Tsetse Research Department, Tanganyika Territory, having made his first acquaintance with the Carabid, *Eccoptoptera cupricollis* Chd., wrote to me as follows: " Singida, 9th Dec. 1935. Outside the house is the burnt and charred ground of last year's clearing. Running over this was what I took to be a large Mutillid. It ran fast. I thought I would like it, but feared to pick it up in case I got stung. As it tried to run away I whisked it back quickly with my fingers, it then would emit the sizzling stridulation of a Mutillid. Finally I walked it into the bottle, congratulating myself that my cunning was greater than that of the rapidly moving noxious insect. On taking the stopper off to have a look imagine my feelings of chastisement to find that I had secured, not a Mutillid, but a harmless Carabid. Two days later I did secure a real Mutillid who was doing the same thing but walking a bit slower."

On the 30th December, Mr. Burtt wrote again: " The mimic I sent you I can't understand. I have had two natives on with it since. They thought it was a Mutillid and would hurt, and would not at once catch hold of it. I have seen the beetle often since, but I have never again heard it stridulate, I am sure I heard the one I sent you, which was a male. These others are females, which may account for it."

It is most interesting to hear of another complete deception by this well-known mimic. Sir Guy Marshall, F.R.S., drew attention to it in 1902, *Trans. ent. Soc. Lond.*, **1902**: 511–12, and wrote of it as " a splendid mimic, and it has caused me to hesitate more than once before venturing to handle it." In 1915 I was myself completely deceived on the banks of the Kagera river, when first meeting *Eccoptoptera*, and about a fortnight later encountered a spider which was actually bottled as a *Mutilla* (1919, *Proc. ent. Soc. Lond.*, **1918**: xcvii–xcviii). In 1921 (*Trans. ent. Soc. Lond.*, **1921**: 43–44) I gave an account of an experiment on a monkey with *Eccoptoptera* which certainly was afraid of it at first. In this case it was noted " this mimetic beetle seems to have lost the extremely unpleasant acrid smell emitted by most members of its family—it could not be made to produce it."

The observation of stridulation in *Eccoptoptera*, which so greatly added to the mimetic effect, is most interesting, and it is hoped that further observations will be forthcoming on the means whereby the noise is made, whether it is, as Mr. Burtt suggests, confined to the male sex, and whether, as I suggest, the beetle has lost the characteristic Carabid odour. It is not common for mimicry to be better developed in the male sex. I have sometimes been particularly struck by the loud twittering noise produced by a *Mutilla* when confined in a box.

A search through references found with the help of Mr. H. E. Andrewes and Dr. B. M. Hobby shows that while stridulation has not been recorded in *Eccoptoptera* it is known in closely allied Carabids.

Thus Péringuey, 1896, *Trans. S. Afr. phil. Soc.*, **7**: 335, wrote of *Microlestia tabida* Fabr. as " the only species [of the tribe Anthiades] I know which produces a stridulating noise," and in his description of *Eccoptoptera cupricollis* Chaud., and another species, *mutilloides* Bert. (*loc. cit.*: 338–9) makes no mention of stridulation.

Rousseau *in* Wytsman, 1905, *Gen. Insect.*, **38:** 3, wrote: "*Microlestia tabida* possède aussi un autre moyen de défense, celui de produire certain son stridulant, probablement par le frottement des pattes contre le rebord de l'élytre."

H. E. Andrewes, 1929, *Fauna Brit. India, Coleoptera*, **1** : 18–20 points out that in the Indian region only one genus of CARABIDAE, *Siagona*, is known to stridulate, and quotes a list of genera, in which stridulation is known to occur, given by Dudich in 1921, *Ent. Blatt.*, **17** : 145–155, which does not include *Eccoptoptera* (or *Microlestia*).

A species of Clerid taken by Canon St. A. Rogers at Mombasa, 1908–11, mimicking beautifully a Mutillid taken in the same locality by the same naturalist, was also exhibited. The former identified by Dr. K. G. Blair as *Thanassimus mutilloides* Klug; the latter by Mr. R. B. Benson as *Odontomutilla microcephala* André. I am greatly obliged to these gentlemen for the identifications.

Postscript.

On the evening of the meeting I received a letter from Dr. Llewellyn Lloyd, F.R.E.S., saying, "In Rhodesia I was much struck with the mimetic resemblance of *E. cupricollis*, though I do not recall the stridulation. I send a group of insects from Ngoa on the Congo Zambezi watershed which I think will be of interest in connection with your exhibit. The Cicindelid *Dromica eriksoni* Horn develops the red on the base of the elytra instead of on the thorax." Among the mutilloid species was a Megalopodid beetle, *Sphondylia mutillaria* Clk., showing oblique elytral markings in the position of the white abdominal markings of *Mutilla*, and a small Reduviid (undet.) with red thorax and white marks at the base of the abdomen. The former is not mentioned by Marshall (*loc. cit.*). Dr. Lloyd also sent examples of the *Polyhirma*, *Piezia* and *Graphipterus* black, white-spotted, association mentioned by Poulton on p. 513 in Marshall's paper. One of these is another species of *Eccoptoptera* (*E. lagenula* Gerst.) which is interesting.

BOOK NOTICE.

R. E. SNODGRASS, *Principles of Insect Morphology*. pp. ix + 667, text illust. 8vo. New York and London (1935). McGraw-Hill Publishing Co., Ltd., 36*s*. 0*d*.

This book is one of the "McGraw Hill Publications in the Zoological Sciences" series.

The 19 chapters of the book deal with the general organisation and development of insects, the body-wall and its derivatives, the regions of the body, and the appendages, the parts of an insect and its organs, the respiratory and nervous systems, sense-organs and organs of generation and reproduction. 22 pages of references and an index complete the book.

The author gives generalisations wherever possible and states that "each of the several chapters of the book . . . is an attempt to give a coherent morphological view of the fundamental nature and the apparent evolution of a particular group of organs or associated structures." Many of the illustrations have already appeared in the author's well-known papers published by the Smithsonian Institution and which are now mostly unobtainable.

The book should be most useful, bringing, as it does, Snodgrass's ideas together.

THE APOSEMATIC LARVA OF *BRITHYS PANCRATII* CYR. DISTASTEFUL TO GUINEA-FOWL, AND ODORIFEROUS WHITE MOTHS REFUSED BY A GALAGO

By Professor G. D. Hale Carpenter, F.R.E.S.

Mr. R. E. Moreau of the East African Agricultural Research Station, Amani, has sent me the following notes which I quote verbatim.

"19th March, 1936. We always have some tame birds about the place, we have never been able to persuade any to take those beastly black and yellow caterpillars of *Brithys pancratii* Cyr. Recently we had three species of Guinea-fowl, used to being fed with insects from the hand. *Guttura pucherani* Hartl., and *Numida mitrata* Pall., always refused to touch or even approach the *Brithys*. One evening we tried them for the first time on an *Acryllium vulturinum* (Hardw.) which had been brought up from a chick. He pecked one, dropped it, and was so disgusted that for the rest of the day he would not take from the hand even his favourite grasshoppers."

The larva of *pancratii* is described by Hampson in his catalogue of the Noctuidae (British Museum, 1905) as having the head, front of 1st somite, and legs, yellow; the rest brown with yellowish-white spots and broad lateral and ventral yellowish-white bands. There are brown warts, each with one hair; the sixth wart on somites five to nine placed on white spots. The larva of another species, *B. crini* Fabr. occurring in India, Ceylon, Singapore and Java is somewhat similarly coloured. *B. pancratii* occurs from south-west Europe through Algeria to Nigeria, and in South Africa as far as Grahamstown; also in Mauritius.

In another note Mr. Moreau writes: "A small galago we had free was keener on moths than any bird I have ever seen on butterflies. He had strong likes and dislikes, always ignoring those species, usually with a good deal of white or yellow, which stink like Pentatomids."

HISTOLYSIS OF MUSCLE IN THE PUPA OF THE BLOW-FLY *LUCILIA SERICATA* MEIG.

By A. C. Evans, F.R.E.S.

(*Department of Entomology, London School of Hygiene and Tropical Medicine.*)

Introduction.

It has been clearly demonstrated that the histology of larval muscle in the young pupa occurs in several ways. Perez (1910) in his extensive work on *Calliphora erythrocephala* has shown that leucocytes invade the histologically unchanged muscle and ingest fragments of it which are then digested in the cytoplasm of the leucocyte. Terre (1899) has shown that phagocytosis plays no part in the breakdown of muscle in the pupa of the bee, while Anglas (1900) who studied a wasp shows that penetration of the leucocytes can precede or follow histological changes in the muscle.

The work described here is designed to show that the mechanism of histolysis of muscle is quite different in its early stages in the two closely related species *Calliphora erythrocephala* and *Lucilia sericata*.

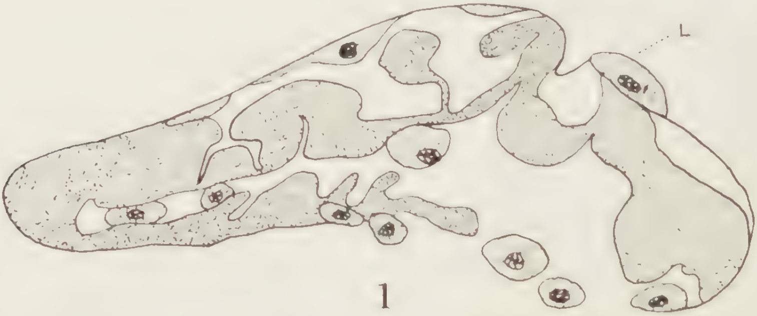

Fig. 1.—Phagocytosis of muscle in *C. erythrocephala*.

General.

In young pupae of *Calliphora* extensive phagocytosis of striated muscle may be easily demonstrated by staining serial sections with haematoxylin and eosin (fig. 1). Perez (1910) has described the process in detail, and an account of the changes which occur will not be given here. The same author described some muscles which are not phagocytised but which pass by a process of dedifferentiation and redifferentiation into adult muscles. These muscles lose their fibrillar structure and become homogeneous, myoblasts migrate into this mass and the adult muscle develops from this.

In the full-fed larva of *Lucilia* the muscles exhibit the familiar cross-striation in longitudinal section. In cross-section the densely staining fibrillae (myoplasm) are embedded in a faintly staining, more or less homogeneous sarcoplasm which contains one or more large nuclei (fig. 2 a). Preliminary changes in the muscle may be observed during the prepupal stage and become very evident in the "white pupa." Histolysis does not occur uniformly in all muscles; muscles exhibiting their typical structure may be found next to muscles in an advanced stage of histolysis. One of the first indications of histolysis is a collapse of the sarcoplasm which often forces the nuclei into the myoplasm. The sarcoplasm

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loses its structure completely and may only be seen with difficulty, surrounding the myoplasm. Here again, however, the course of events is not uniform, sometimes a typical sarcoplasm may be found surrounding a degenerating myoplasm. Green (1933) has noted in the pupa of *Vespa* that there is a considerable variation in degree of development of different parts of the alimentary canal in different individuals of the same age. On the other hand, Perez (1910) described phagocytosis of muscle as commencing in the anterior region of the pupa and passing progressively towards the posterior region. There is no evidence of any such progressive antero-posterior histolysis in *Lucilia*.

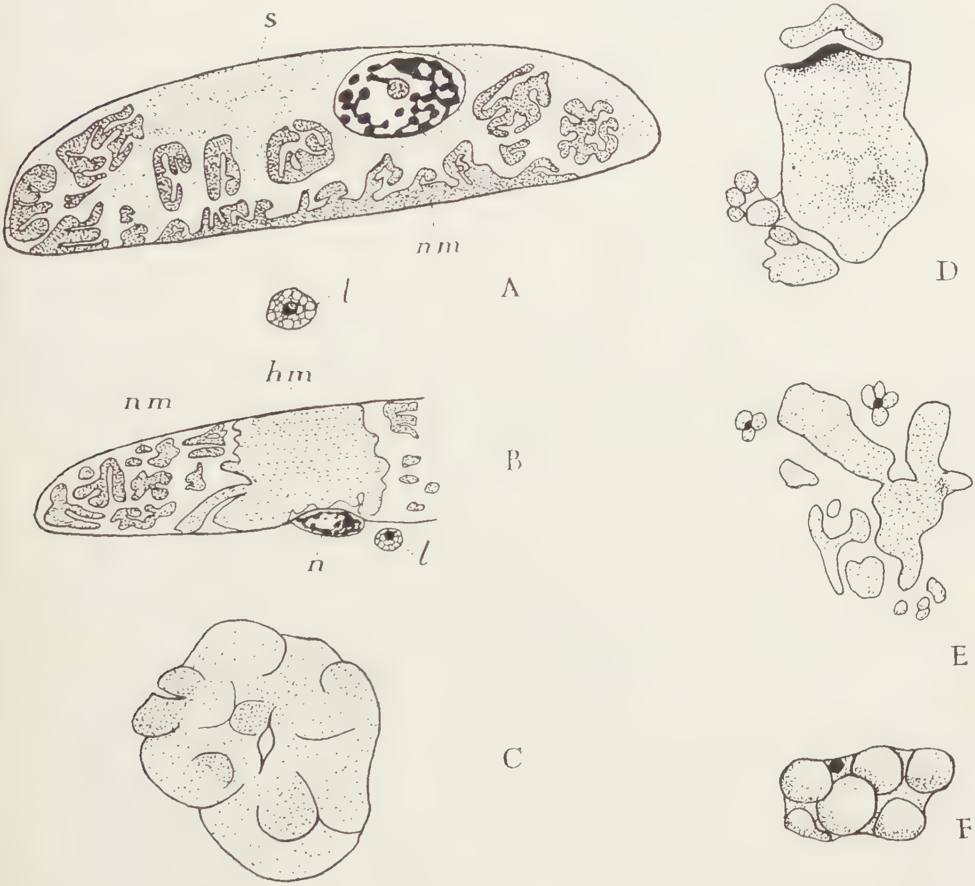

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Fig. 2.—Progressive histolysis of muscle of *L. sericata*.
For explanation of A–F see text. *l* = leucocyte; *nm* = normal myoplasm; *hm* = homogeneous myoplasm; *n* = nucleus; *s* = sarcoplasm.

Degeneration of the myoplasm commences with a condensation of the fibrillae, which lose their striated appearance and in cross-section appear homogeneous (fig. 2 B, C). Several of these homogeneous masses may be found in one muscle, so degeneration does not occur simultaneously throughout the muscle. When the muscle becomes completely homogeneous it loses its typical elliptical shape as seen in cross-section and becomes rounded (fig. 2 C). Further changes now occur inside the muscle, which begins to break up into small pieces. These small pieces break away singly or in clumps (fig. 2 D, E). Some muscles at this stage present a fenestrated appearance; since this structure could not be brought about by pieces breaking away from the interior of the muscle it is possible that local liquifactions occur, the products of which diffuse away. Thus, by stages, the muscle is reduced to numerous small rounded fragments. Histolysis of all muscles is complete on the second day after pupation, there is no conversion of larval into imaginal muscle as described by Perez (1910) for *Calliphora*.

While these changes are occurring leucocytes are present in large numbers in the blood, but no special aggregation occurs in the vicinity of muscles undergoing histolysis. The leucocytes are spherical cells with reticulate cytoplasm and distinct nuclei. In one instance only could anything approaching phagocytosis of undifferentiated muscle be discerned. Several nuclei were present in two pairs of muscles lying beneath the brain, but, even here, the nuclei were extremely sparse when compared with the number figured for *Calliphora*.

Although the leucocytes play no part in the histolysis of muscle, they appear to play a very important part in the digestion of the small pieces into which the muscle is resolved. Several of these small pieces are ingested by each leucocyte and give rise to the granular spheres of Perez (1910). From this point onward the process is similar in both *Calliphora* and *Lucilia*. The muscle fragments are slowly digested and the products of digestion utilised in the building up of the imaginal tissues. The granular spheres disappear about two days before the eclosion of the imago. The amount of muscle which a leucocyte can ingest is surprising, comparison of the leucocytes in fig. 2 A and B with the granular sphere in fig. 2 F, will give an idea of their capacity in this direction.

SUMMARY.

In the Muscid flies *Calliphora erythrocephala* and *Lucilia sericata* the histolysis of larval muscle may be divided into two parts :—

(*a*) Division of the muscle substance into small particles.

(*b*) Digestion of these particles by leucocytes.

In *Calliphora* leucocytes are concerned in both the particulation and digestion of the muscle substance; in *Lucilia* autolysis and fragmentation of the muscle occurs independently of the leucocytes, which are only concerned in the ultimate digestion of the muscle fragments.

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PRECOCIOUS ADULTS RESULTING FROM THE OMISSION OF THE FIFTH INSTAR IN *LOCUSTA MIGRATORIA MIGRATORIOIDES* (R. & F.)

By K. H. L. Key, M.Sc., Ph.D., D.I.C., F.R.E.S., and
E. Berry Edney, B.Sc.

Wigglesworth (1934), in his ingenious experiments on the hormonic control of moulting and metamorphosis in *Rhodnius prolixus* Stål, has shown that a precocious metamorphosis may be induced in the nymphs of this insect by experimental means. If a nymph of any of the first four instars is decapitated soon after feeding, and is attached to a fifth-instar nymph decapitated after the critical period, in such a way that the body fluids of the two nymphs are free to intermingle, it is found that in a high proportion of cases the two nymphs moult almost simultaneously, and the young nymph is seen to have acquired adult characters to a greater or lesser degree.

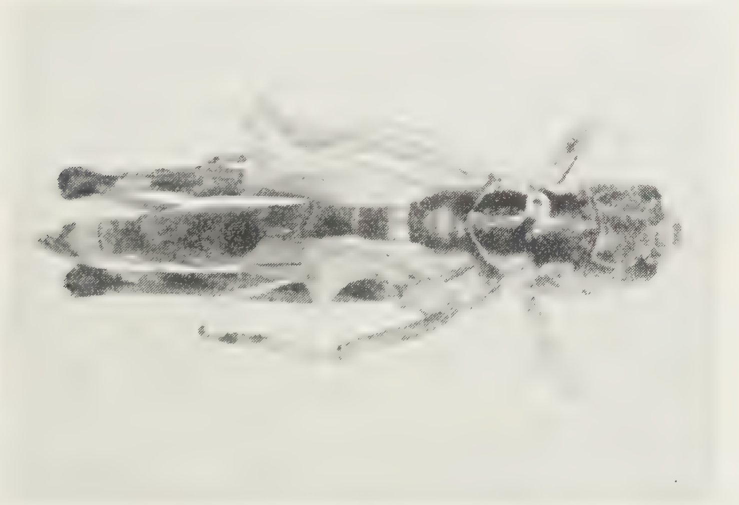

Fig. 1.—A precocious male, dorsal view.

In view of this discovery, it is interesting to find that precocious adults apparently occur "spontaneously" under certain conditions in the locust *Locusta migratoria migratorioides* (R. & F.). A stock culture of *Locusta* was being bred by the authors during 1935, and it was observed that out of many thousands of insects produced in the cages used, three nymphs moulted directly from the fourth instar into a form which undoubtedly represents a precocious adult similar to those obtained experimentally in *Rhodnius*, and did not thereafter moult again, the fifth instar being thus completely omitted.

Conditions of Culture.

The breeding cage used was substantially the same as that described by Hamilton (1936). It consisted of a metal frame with glass sides and roof, the latter being provided with a small door. The floor was covered with a layer of about 3–4 ins. of moist sand, in which the eggs were laid. Artificial heating was provided by means of a small electric heater inside the cage, resting on the sand.

This heater was controlled by a thermostat in the centre of the cage, to give a temperature of 35–40° C. In a cage of this kind, having damp sand covering the whole of the bottom, the relative humidity at any given temperature remains practically constant, and its value depends upon the degree of ventilation. This was adjusted in the cage used to give a relative humidity of about 60% in the centre of the cage. Artificial lighting was provided by means of a 50-watt gas-filled bulb near the centre of the cage. It will be realised that the conditions inside such a cage would not be uniform in all parts. There were definite gradients of temperature, light intensity and humidity, and the distribution of these conditions in the cage was mapped. Without going into detail, it may be stated that the soil temperature at a depth of about three inches varied from a minimum of about 25° C. in the corners to a maximum of about 29° C. near the heater. The surface temperature varied from about 29° C. in the corners to about 32° C. in the centre, while the temperature at the centre of the top of the cage was about 40° C. The relative humidity, similarly, varied from about 80% at the surface of the soil to about 50% at the top. Both lighting and heating were maintained continuously day and night. Food was supplied in quantity once a day, and was usually consumed before the next feeding time. The number in the cage at one time extended to many hundreds, and was sufficient to produce phase *transiens*.

The above rather detailed description of the conditions of culture has been given because it is quite unknown which external conditions, if any, should be held responsible for the appearance of the precocious adults, and the conditions employed manifestly depart in important respects from those normal to the species.

Description of the Abnormal Individuals.

The three specimens showing the abnormality comprise two males and a female (figs. 1, 2). Morphologically, all three are essentially undersized adults in which the wings are somewhat crumpled and about one-third the normal size, the whole insect being about three-quarters, or less, of the normal size. The wings and elytra are membranous and possess nearly typical adult venation. They are not closed, but rise up at an angle, and the surface of the elytra is approximately horizontal instead of approximately vertical. The external male genitalia are practically normal, though the subgenital plate is somewhat shorter and less swollen. The internal genitalia, also, have all the normal structures, but are somewhat smaller and less strongly sclerotised than normal.

In the female the genital valves are poorly sclerotised, not as strongly curved as in the normal adult, and the lower pair is distinctly shorter than the upper pair, thus resembling the fifth instar. As regards thickness of cuticle and shape of pronotum, all three specimens are typically adult. Also the coloration in the female and one male is that typical of the adult. In general the nymph of phase *transiens* has the median region of the disk of the pronotum black, the lateral parts being paler, while the adult has the median region pale, with a black stripe on either side; further, the adult has no orange pigment, and the mandible is marked with black and blue. The other male, though adult in other aspects of coloration, has a certain amount of orange pigment on the head, lateral lobes of pronotum, and hind femora.

Sexual Development.

In order to study the development of sexual behaviour in the abnormal individuals, and also, if possible, to obtain progeny from them and thus ascertain whether the abnormality was hereditable, the two males were placed in separate cages with normal females, and the female in a cage with a normal, sexually active male. One of the males showed in due course the lightening of colour associated with sexual maturation, and was observed to attempt to copulate. The usual signs of sexual excitement were also evident. No actual case of successful copulation was observed, however, and though the female laid eggs, these did not hatch. This may or may not have been due to lack of impregnation by the male. In order to ascertain whether the testis was producing sperm, the insect was killed and the testis examined. This examination showed that numerous sperms were present, and the testis appeared to be in normal condition. The other male died before becoming mature.

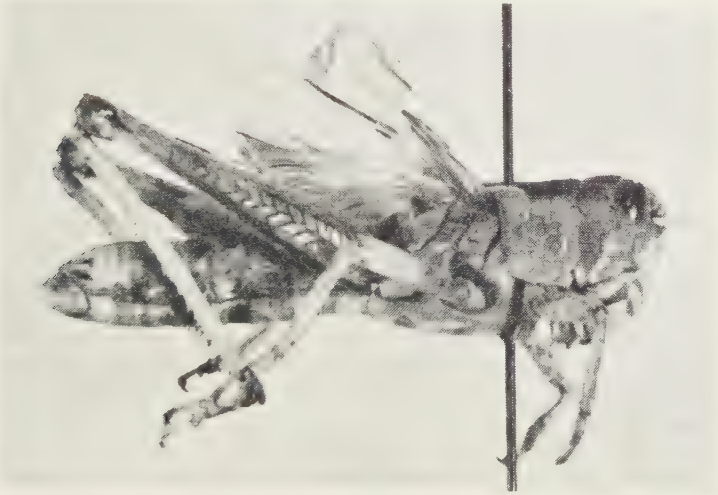

Fig. 2.—A precocious male, lateral view. × 3

In the case of the female mated with the normal male, attempts at copulation were again observed, but in no case with success. However, the ovaries developed normally, and were apparently of normal size, for the abdomen became quite abnormally distended, and finally the insect died without depositing eggs. Upon dissection the ovaries were found to be quite normal, and full of eggs, some of which had passed down one oviduct, but had not been able to pass beyond the point of junction of the two oviducts. There appeared to be a blockage of the common duct, perhaps due to its being too narrow, and the abdomen beyond the point of junction was not distended, and appeared dead.

Discussion.

The above observations appear to justify the conclusion that the individuals under consideration are physiologically normal adults, but that their normal functioning as adults is interfered with because they are in certain respects *structurally* immature. Thus it seems doubtful whether either the male or the female copulatory apparatus is capable of functioning properly, though the genital products are successfully produced, and adult behaviour exhibited. In the case of the female the vagina appears too small to allow the passage of the eggs.

Interpreting the facts in the light of Wigglesworth's conclusions regarding the presence, in all instars but the last, of an inhibitory hormone which delays metamorphosis, and thus permits of growth in size, and whose absence in the last instar leads to metamorphosis,* we must conclude that in the spontaneously occurring precocious adults of *Locusta* the concentration of the inhibitory hormone has for some reason fallen below the minimum for its effectiveness one instar earlier than normal; that is, in the fourth instead of in the fifth. It should be noted that the three abnormal individuals are practically identical in structure, that no intermediates between their condition and the normal were found, and that all three failed to pass through a (morphological) fifth instar. Since their appearance was quite unexpected, and was not repeated, no special precautions had been taken to count the number of *stadia* passed through, and it is thus not possible to affirm that the last nymphal instar represents a chronological as well as a morphological fourth (Key, 1936). That it was morphologically a fourth instar was established for two of the three by examination of the last cast skin.

The cause of the variation in the number of instars within an insect species is obscure. Where it involves an increase of the normal number of instars, it appears, at least in *Locusta* to be brought about by the duplication of some specific instar, though not always of the same instar (Key, 1936). The fact that the various instars, particularly the later ones, are clearly characterised by certain morphological features, and that intermediates between them do not seem to occur, emphasises the fact that metamorphosis is really progressive, proceeding by a succession of stages, of which the last is, however, incomparably the greatest. The explanation of the phenomenon, when formulated, will presumably be in terms of hormonic activity, and any such explanation will have to account for the observed duplication of certain instars in the case of the six-instar cycle.

But where, as in the present case, we find a *reduction* in the number of instars, with the production of precocious adults, we have to explain why the inhibitory hormone ceased to be secreted an instar earlier than normal. We have evidence for believing that the six-instar cycle is an hereditable variation, and it seems quite probable that the development of precocious adults is also, and it is therefore most unfortunate that it proved impossible to breed from what might have proved an interesting mutant. The possible effect of external factors as a cause of the abnormality must not, however, be lost sight of, though this seems a less likely explanation in view of the very small number of abnormal individuals.

The observations which form the subject of this paper were made in the research laboratory of the Department of Zoology and Applied Entomology of the Imperial College of Science and Technology. The authors wish to thank Professor J. W. Munro and the departmental staff for the facilities provided.

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* Note the alternative explanation mentioned by Wigglesworth.

THE HIBERNATION OF *NYMPHALIS POLYCHLOROS* (L.) IN GREECE (LEPIDOPTERA)

By R. C. Shannon.

(*Malaria Division, Rockefeller Foundation, Greece.*)

Communicated by Prof. P. A. Buxton, F.R.E.S.

The remarkable hibernation of *Nymphalis polychloros* (L.) can better be appreciated by comparing its behaviour with that of its famed ally, the "Painted Lady" butterfly, *Vanessa cardui* (L.).

"*V. cardui*, probably the greatest migrant in the world (next to man), ranges from the equator to the Arctic Circle, from sea-level to mountain tops, and is found in every continent of the world with the possible exception of South America. Nearly every year migrations are observed proceeding from Africa (possibly originating south of the Sahara) to various parts of Europe. Offspring of the early season migrants may eventually reach Iceland. Migrants from the American continent have even been found in Hawaii, 2000 miles distant from California, the nearest mainland approach. There is but little evidence of return migrations to the permanent breeding areas or of overwintering in any stage in the lands which the migrants have reached" (Williams, 1930).

The behaviour of *N. polychloros* by contrast is at the other extreme. Apparently but little is known regarding its biology, doubtless due to its being one of the most retiring of butterflies. Actually it goes into deep retirement, seeking its resting-place in dark, cool cave-like retreats in May and remaining there until the following spring.

The present observations began in May, 1934, when about 25 individuals were found in the rear end of a horizontal tunnel (1·5 × 1·5 × 15 metres) which had been excavated in a clay bank, near Kerkini Weir, upper Struma Valley, Greece.

Specimens were found suspended from the ceiling in a state of complete torpor, where they remained month after month without movement. Nothing aroused them unless they were bodily removed. When carried out in the open and released they dropped apparently lifeless to the ground, where they remained without movement until warmed by the sun. This required upwards of a minute. On recovering "consciousness" they would fly a short distance and then alight. After a brief rest they would fly about bat-like, seeking a dark opening. A few would locate the entrance to the tunnel and re-enter, but most apparently found shelter elsewhere.

The undisturbed individuals were seen as late as November. Apparently they remain in hibernation until early in the following spring. None was seen the following April, but before the end of May 1935, a new set had appeared in the tunnel.

PROC. R. ENT. SOC. LOND. (A) 11. PT. 3–5. (JUNE 1936.)

Similar observations were made in 1933.

While visiting the region last June, Professor P. A. Buxton dissected several individuals with the following results. Both sexes were present and both had heavy layers of yellow fat. Their alimentary tracts were empty save for a brownish mass in the rectum, possibly composed of excreta from the malpighian tubules. The ovaries of the females were so undeveloped that they could not be located in the dense layers of fat. The testes of the males were full of spermatozoa, which, however, were not motile, possibly because of immaturity or to having been killed by being dissected in water.

The pupation of this species is likewise a curious phenomenon. Several temporary wooden structures were erected in a nearby village (Lithotopos), and on their completion in early May a number of Nymphaline pupae was observed attached by very short silk strands to the ceiling. Adults reared from these proved to be *N. polychloros*. Evidently the larvae, like the adults, are motivated to seek cave-like, or house-like structures, doing so for the purpose of pupation. The pupae retain a certain degree of motility until nearly mature. When the earlier stage pupae are touched they swing themselves violently from side to side, striking the ceiling with their anterior ends with a distinctly audible sound. The pupation period lasts two to three weeks.

Prof. Buxton further informs me that elsewhere in Europe the larvae feed on elm leaves. Members of the genus *Ulmus* are abundant in the area where these observations were made. With these data it is possible to construct in a general way the course of the life-history of the species as it occurs in Greece.

The eggs are oviposited, presumably, on elm trees in the early spring (possibly in March or even in February). The larvae either undergo a rapid development lasting a month or two or remain in this stage until the following year. Pupation occurs in late April or early May, the period lasting two or three weeks. Both sexes, having retained heavy stores of fat from the larval stage, enter hibernation shortly after emergence and before mating. They remain in hibernation from May until the following spring, when they mate and the females oviposit. There is, therefore, but one brood a year, or possibly one every two years.

Inasmuch as the butterflies are dormant throughout the summer it may be proper to consider this a case of aestivation. But, because they continue dormant until the following spring, it would appear preferable to regard it as an abnormally long hibernation, lasting probably nine to ten months. In connection with this it should be noted that the temperature at the rear end of the tunnel and in other similarly dark, damp situations where additional specimens were found, ranged between 20 to 25° C. throughout the summer and possibly did not go below 15 to 12° C. during the winter.

Finally, it is of interest to repeat another statement given by Williams: "It has often been pointed out, particularly in discussions on the migrations of birds, that migration appears to have developed as an alternative to hibernation."

The extraordinary migrations of *Vanessa cardui* and the extraordinary hibernation of a related species (*Nymphalis polychloros*) would appear to furnish additional evidence to support this belief.

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NYMPHALIS POLYCHLOROS L., IN THE SOUTH OF FRANCE

By Fleet-Paymaster T. Bainbrigge Fletcher, R.N.

In 1932 I was at Hyères from 7th May to 13th July and again from 8th September until the end of January 1933. On 11th June I bred one *Nymphalis polychloros* from a pupa found on a gate-post on 3rd June, and the first examples of this butterfly were seen on the wing on 16th June and it was present in small numbers until 2nd July. On my return in September I expected to see it still about, but the only one which I saw on the wing in the autumn was one rather tattered individual on 7th November. It would seem, therefore, that in the south of France *N. polychloros* is on the wing for quite a short period after emergence in the summer and commences to hibernate (if this term is applicable) early in July.

A DESCRIPTION OF A NEW TYPE OF LARVAL RESPIRATORY ORGAN IN *ATRICHOPOGON TRIFASCIATUS* KIEFF. (DIPTERA, CERATOPOGONINAE)

By E. T. Burtt.

(*Sub-Department of Entomology, Zoological Laboratory, Cambridge.*)

Communicated by Dr. W. H. Thorpe, F.R.E.S.

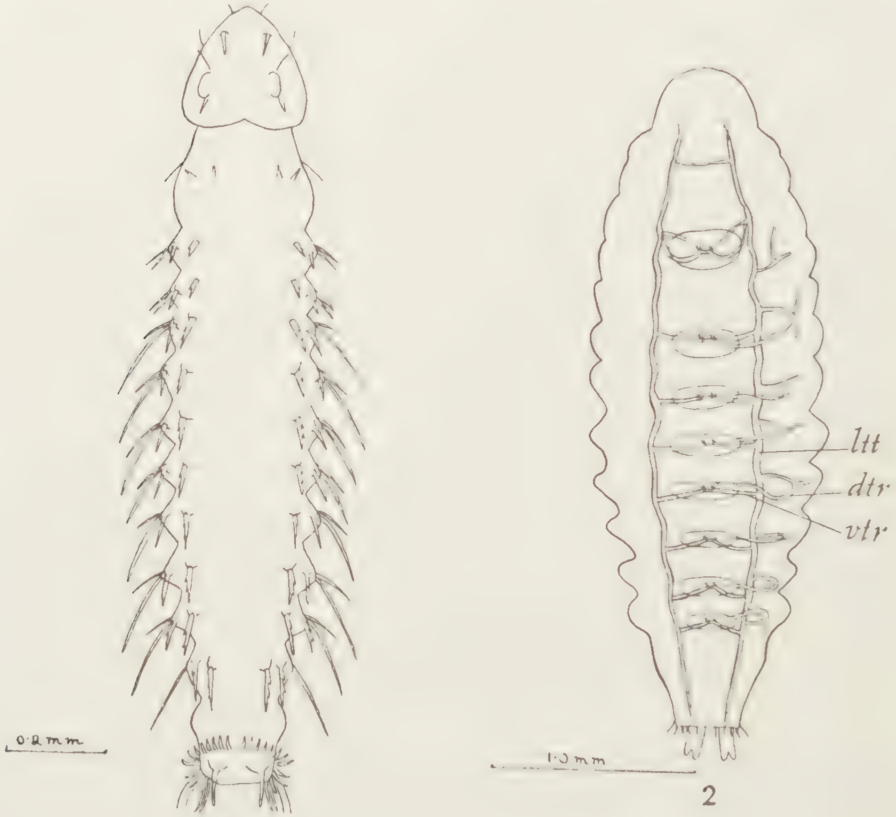
The life-history of *A. trifasciatus* was studied at Lake Ohrid, in Yugoslavia, which I visited in 1935 in the course of a tour in the south-west Balkans. The developmental stages of this insect are all passed on stones in fresh water; they occur in both streams and lakes, but are never found in stagnant waters. The ova and larvae are found only on the stones which are half submerged, and are sharply restricted to the region between the water-level and the upper edge of the moist film.

Ova.

Lenz described oviposition. The eggs occur in groups numbering up to about 30. They are elliptical, 0·4 mm. long, with a finely pitted surface, and dark brown in colour. The duration of the egg-stage appears to be about ten days.

Larva.

The last-instar larva is described by O. W. Müller and Lenz, as regards its external features and arrangement of bristles. It is dorso-ventrally flattened and the segments are drawn out laterally into conical projections from the tips of which spring curved bristles. On the dorsal surface are eight elliptical cushion-shaped areas which are devoid of the small warts covering the rest of the body surface. The first-instar larva (fig. 1) is 0·7 mm. long, and differs from the later stages in the absence of certain bristles, and also of the characteristic dorsal cushions. These last, however, are found on the second instar larva and occur in all the later stages.



Figs. 1–2.—(1) First-instar larva ; (2) Tracheal system of last-instar larva.

I did not succeed in rearing larvae beyond the second instar. Measurement of the head-widths of a collection of larvae indicate that there are four instars, but the form of the larva is very similar in the last two.

Feeding Habits of Larva.

The larval food at all stages consists of the incrustation of algae and diatoms which is scraped off the stones. The structure and mode of action of the mouth-parts are similar to those of *Forcipomyia* described by Saunders. The gut was examined and found to be closely similar, and the Malpighian tubes are two in number.

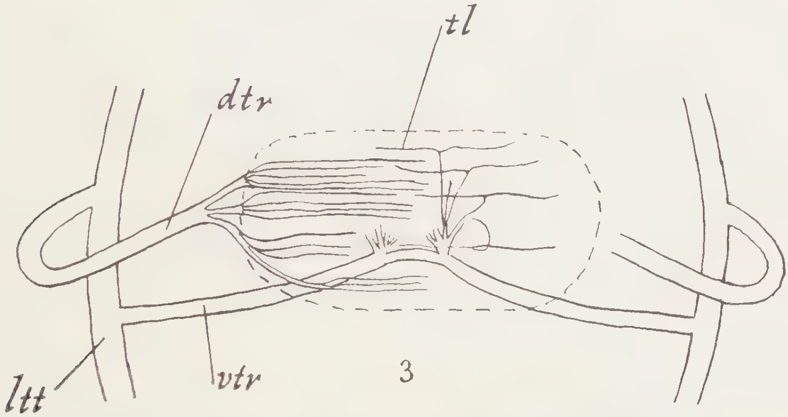


FIG. 3.—Diagram of tracheal supply to respiratory organ.

Respiratory System of Larva.

Special interest attaches to the tracheal system of the larva (fig. 2) and its relation to the above-mentioned dorsal cushions. The tracheal system is completely closed, as is general in the CHIRONOMIDAE. It consists of two longitudinal trunks united by dorsal commissures in the 1st, 2nd and 4th–10th segments. It supplies the head, gut and body wall, but its largest branches run to the tissue underlying the dorsal cushions. These last have a double tracheal supply; one pair of branches enters each one of them laterally from the trunk, and another pair ventrally from the region of the commissure.

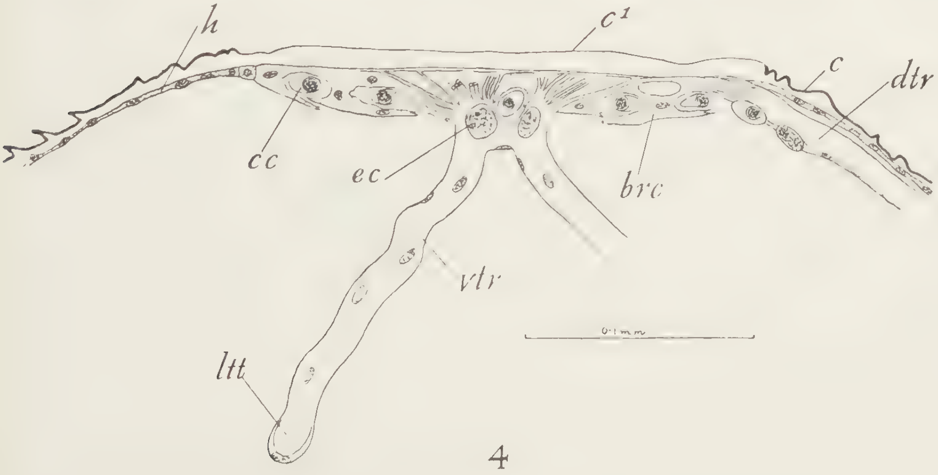


FIG. 4.—Section of respiratory organ; the cuticle has become detached from the underlying cells during fixation.

In the living specimen these trachea are seen to break up and spread out as fine parallel tracheoles immediately beneath the cuticle (fig. 3). Whether the tracheoles of the two sides anastomose or not is not easy to make out. They appear as very fine lines close together, and one cannot say exactly where any given tracheole ends. Even when the larvae were asphyxiated by being confined under a coverslip, no extension of the air in the tracheoles was apparent.

Larva were fixed in alcoholic corrosive acetic, and preserved in 70% alcohol with iodine added. The material was embedded in paraffin wax, and numerous transverse and longitudinal sections were cut, and stained either with iron haemotoxylin or Mallory's Triple Stain.

In transverse section (fig. 4) it is seen that the cuticle in this region is much thinner than over the rest of the body. The application of the chitosan test shows that the cuticle is chitinous even in the thin areas. The hypodermis in this part, on the other hand, is thickened, and the cells greatly hypertrophied, whilst elsewhere it consists of flattened cells with small nuclei. This enlarged hypodermis consists of three elements: (1) branching cells with small nuclei supporting in their interstices, (2) compact cells with larger nuclei, (3) trachea, with obvious membrane cells, but no spiral thickening, passing to tracheal end cells and their resulting tracheoles.

The tracheoles arising from the ventral trachea pass up to the surface of the hypodermis, branch into two, and the resulting branches pass in opposite directions on the surface (fig. 3). The lateral tracheae, on the other hand, split up into tracheoles which pass out over the surface directly.

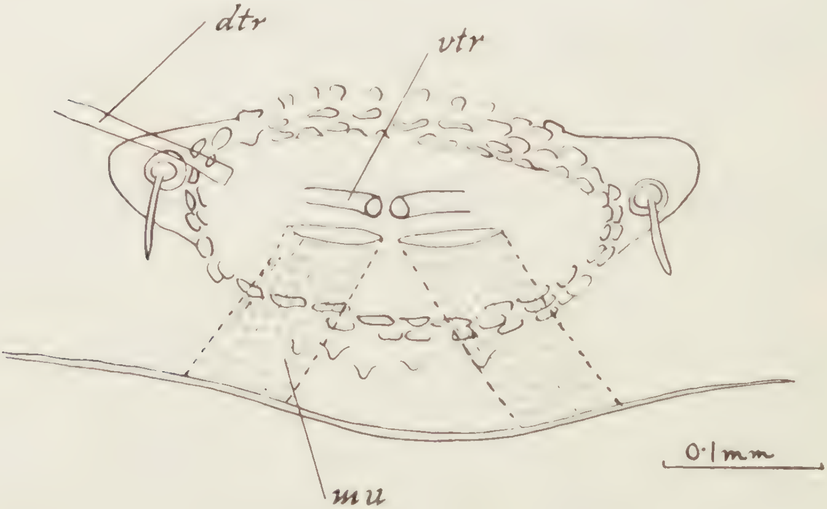


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FIG. 5.—Organ from above showing muscles and surrounding scales.

A pair of muscles is attached at their anterior ends to the cuticle in the central region of the organ (fig. 5). Posteriorly they pass to the hind margin of the segment. When these contract they pull the surface downwards so that a trough is formed, which is more or less closed by the scales at its sides. This contraction will take place if the cushion is touched, or if the larva is allowed to become dry.

From its structure there seems to be little doubt that the organ is respiratory in function. The larva is confined to the moist region of the stones, I have never succeeded in finding it below the water-mark, and never on the dry parts. Under these conditions it is covered with only a thin film of water, and so the organ would appear to be functioning as a lung, and effecting gaseous interchange with the atmosphere through a very thin film of water.

The restricted habitat of the larva suggests that it needs atmospheric air. No definite evidence could be obtained on this point, for whereas immersion in still water in the laboratory killed the larva in ten hours, immersion below the surface of the streams for 36–48 hours had no apparent injurious effects. The water in these streams is nearly saturated with oxygen, hence if the water is passing rapidly over the surface of the organ, the oxygen tension at this point will approximate to that when exposed to the atmosphere.

The ova and larvae cannot withstand desiccation consequent on their removal from the moist region. This determines their upper limit. The pupae resist drying, and occur even on dry parts of the stones.

I wish to thank Dr. W. H. Thorpe for his kind advice and criticism, and Dr. F. W. Edwards for the identification of the material.

Lettering of Illustrations.

c. = cuticle.
ec. = tracheal end cell.
dtr. = dorsal trachea supplying organ.
h. = hypodermis.
mu. = muscle.
ltt. = longitudinal tracheal trunk.
tl. = tracheole.
vetr. = ventral trachea supplying organ.
br. c. = branching cells.
cc. = compact cells.
c′. = thin region covering organ.

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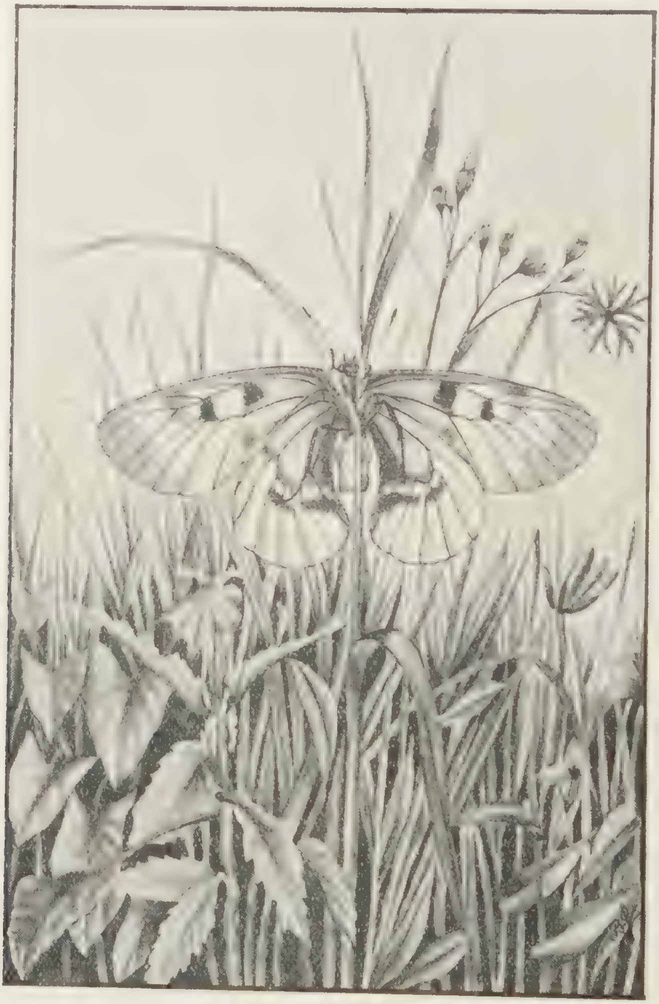
ON THE STRIDULATION OF THE FEMALES OF *PARNASSIUS MNEMOSYNE* L.

By B. Jobling, F.R.E.S.

My observations on the stridulation of *Parnassius mnemosyne* were made in central Russia. I came across the stridulating female of this butterfly for the first time in 1911, when collecting insects about 150 miles east of Moscow. My attention was attracted by a faint rustling sound. Turning towards the direction from which the sound came I noticed *P. mnemosyne* settled on the upper



P. mnemosyne L. ♀, resting position of wings and hind legs during stridulation.

part of a plant about eight or ten feet away. On closer examination I found that the rustling sound was emitted by this butterfly and was produced by scratching the inner surface of the hind-wings with the hind legs. The specimen was a female with a well-developed anal pouch or sphragis.

For the next two years I was unable to study the stridulation of this butterfly, but in 1914 I found a new locality about fifteen miles from Moscow where the butterfly was very common, and here I made observations during three seasons. Before describing these observations in more detail it will be of interest to mention the distribution and habitat of this butterfly. In central Russia it occurs only locally, one habitat being separated from another generally by many miles. The three places known to me were remarkably similar as regards topography, vegetation and eco-climate. Two were a few hundred yards from a river, the other was about the same distance from a small lake. Each was in a moist, shrubby ravine extending in a southerly direction. Through each of these ravines a small stream passed, and on the elevated sides grew a dense wood of very tall trees. Owing to the topographic conditions and the arrangement of the vegetation the haunts of the butterfly were sheltered from the wind and received sunshine for not more than three or four hours a day in midsummer. The area occupied by this butterfly in each ravine was not very large. As far as I can remember, two of the areas measured about one acre each, whereas the third probably did not exceed half an acre. Over this stretch of land the males and females fly very slowly or rest on the plants. They appear never to leave their habitat, since I did not see them on the elevated sides of the ravines nor at the ends, which are usually open, very much exposed to the wind and on which the sun shines for a much longer time. This brief description of the habitat shows that this butterfly is adapted to the sheltered, moist places which are commonly found in ravines.

The butterfly is never very numerous. In a small area occupied by it specimens can all be easily found and counted. Their number is almost constant from day to day for about a fortnight.

I have never seen a specimen in the act of stridulation during the most active period of its life, when both sexes are present together. The stridulation of the females begins after the disappearance of the males. All the stridulating females that I observed were fertilised, since they all had a very well-developed sphragis. In the drawing reproduced here I have tried to show exactly what I saw very often.

During stridulation the female usually holds on to the upper part of a tall plant with its fore and middle legs. Its body occupies the vertical position; the wings are outstretched and bent slightly forwards. The hind legs, which play the most important part in the production of the sound, move up and down, scratching the membrane and the ridged veins of the hind-wings with the strong spines of the segments of the tarsi and the spurs of the tibiae. The strength of the stridulation varies very much in different females; in the more vigorous it is distinctly heard about twelve feet away. The rustling sound can be imitated easily by a gentle scratching of a piece of parchment paper with the point of a pin. An examination of many specimens of this butterfly in the collection of the British Museum revealed no marks of scratching on the inner surface of the hind-wings. It must be mentioned here that in the genus *Parnassius* the inner surface of the wings is not very scaly; in the species in question it is almost completely devoid of scales and is smooth and glossy. There is no special modification in the hind legs of this butterfly, their structure is the same as that of *P. apollo*.

It seems to me that the sound is a protective device, and this view is supported by the absence of stridulation in the males and in the unfertilised females, which are more alert and more often on the wing. The fertilised insects are more commonly found settled on plants. This view is also supported by the fact, which I observed several times, that when the stridulating females are disturbed by the approach of an observer they begin to move their hind legs much faster and produce a louder sound. When frightened they generally drop to the ground or fly a short distance.

In conclusion I express my thanks to Mr. N. D. Riley of the British Museum for the use of specimens, without which I could not have prepared the drawing illustrating this paper.

STRIDULATION IN INSECTS

By Fleet-Paymaster T. Bainbrigge Fletcher, R.N., F.R.E.S.

With reference to his interesting note on stridulation by females of *Parnassius mnemosyne*, Mr. Jobling seems to have noted this only in the case of fertilised females, when no males were present, and in such cases the sound may be of protective significance. Stridulation in *Vanessa io* and *V. urticae* was discussed by A. H. Swinton (1877, *Ent. mon. Mag.*, **13** : 169–172), who stated that he had reason to think that *V. io* will also utter this sound when the male and female are coquetting in the air. Many butterflies and moths are well known to stridulate on the wing, *e.g.*, *Ageronia* in South America and *Nyctipao hieroglyphica* in India, *Cymbalophora pudica* in south Europe, *Hylophila bicolorana* and *Halias prasinana* in England, and such stridulation is doubtless sexual. Allard (1914, *Ent. News*, **25** : 463–466) has noted that stridulation is intimately associated with the mating activities of the musical Orthoptera, exciting rivalry among the males and thus bringing several males to the vicinity of one female. The same modification may, however, serve more than one purpose. Thus, in the common Indian lizard, *Calotes versicolor*, the head and forepart of the male may assume a brilliant red colour, which is of use to the animal concerned (1) in its mating activities, (2) as a deterrent to enemies, and (3) as an attraction to butterflies. Similarly, stridulation in butterflies or other insects may be useful for sexual attraction or for conveying a false warning to enemies. The large Dynastid beetle, *Xylotropes gideon*, when picked up, emits a loud sharp hiss, very disconcerting to any would-be captor not expecting this. When I was rearing some larvae of the large Sphingid, *Langia zenzeroides*, in Shillong, one full-fed larva escaped and crawled under the carpet in a room in the bungalow and, when disturbed, emitted a loud hissing sound, just as if a snake had been under the carpet. This method of intimidation, by the production of a hissing sound suggestive of the presence of a snake, is, of course, very widely utilised not only by insects but by the young of various mammals (cats, bats, etc.) and birds (owls, titmice, woodpeckers; also by the female hoopoe when sitting on her eggs), which have the common habit of nesting in hollow trees or similar dark retreats. It is therefore of interest to note that a hissing noise is also produced by the Vanessid butterflies (*Vanessa io*, *V. urticae* and *V. antiopa*) which normally hibernate in such situations. (See Swinton, *loc. cit.*, and Jones, *tom. cit.* : 208.)

ON THE NOCTURNAL ACTIVITY OF TIPULINAE (DIPTERA) AS MEASURED BY A LIGHT TRAP

(1) THE TIME OF FLIGHT AND PROPORTION OF SEXES

By R. D. Pinchin, B.Sc., and Joan Anderson, M.Sc.

(*Entomology Department, Rothamsted Experimental Station.*)

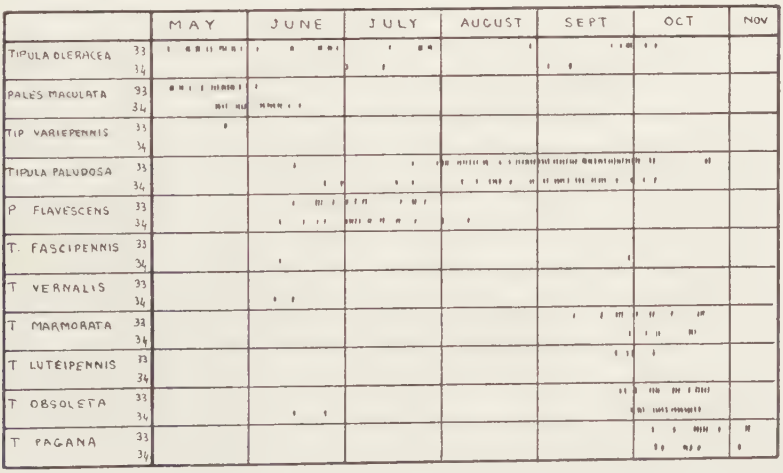
Communicated by Dr. C. B. Williams, F.R.E.S.

Introduction.

The present paper is an analysis of the results obtained from the numbers of crane-flies caught in a light trap at Rothamsted Experimental Station for the two years from 1st March, 1933, to the 28th February, 1935. The light trap in question was designed by Dr. C. B. Williams and is described by him in a previous paper (Williams, 1935).

In the course of this work, the analysis of the 1933 figures has been undertaken by Pinchin, and the 1934 figures by Anderson.

The Tipulinae represent one of the three sub-families into which the Tipulidae are divided. The characteristics of the sub-family are summarised by Audcent (1932).



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The results obtained for the two years show not only what are the most abundant light-loving Tipulinae in the locality (which is about twenty-five miles north of London), but also at what time of year each species is most common, in what proportion the sexes of each species are attracted to light and at what time of the night each species is most active.

The Tipulinae were selected for this analysis on account of their abundance (1256 being caught in 1933 and 836 in 1934), and of the economic importance

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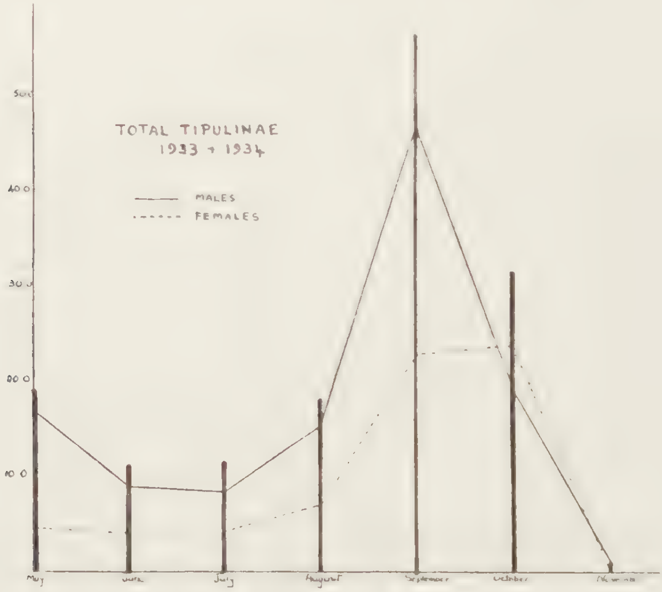
of their larvae (leather jackets), which at times become a pest by destroying young crops and grass.

In the analysis of the figures obtained for the TIPULINAE, the logarithm of the insect number plus one has been taken. The use of logarithms eliminates any inaccuracy in the interpretation of the results due to the swamping effect of one large capture, and the addition of one to the insect number avoids the use of logarithm "minus-infinity" when the catch is zero. This matter has already been explained by Williams (*loc. cit.*).

The authors wish to acknowledge with thanks the assistance they have received during the course of this work from Dr. C. B. Williams.



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ANNUAL DISTRIBUTION OF THE SPECIES CAPTURED.

The total number of species caught in the light trap in the two years from March 1st, 1933, to 28th February, 1935, is eleven. They are :—

	1933.	1934.	Percentage of Total TIPULINAE.
1. *Tipula paludosa* Meig.	787	505	61·8%
2. *Tipula obsoleta* Meig.	159	138	14·2%
3. *Pales maculata* Meig.	128	87	10·3%
4. *Tipula pagana* Meig.	63	33	4·6%
5. *Tipula marmorata* Meig. . . .	43	22	3·1%
6. *Tipula oleracea* L.	51	11	3·0%
7. *Pales flavescens* L.	20	36	2·7%
8. *Tipula luteipennis* Meig. . . .	4	0	0·2%
9. *Tipula fascipennis* Meig. . . .	0	2	0·1%
10. *Tipula vernalis* Meig.	0	2	0·1%
11. *Tipula variipennis* Meig. . . .	1	0	0·05%

Annual Distribution (fig. 1).

The TIPULINAE pass the winter in the larval stage and the imagines are seldom to be found from November to the end of April. They begin to appear in May, the first species captured in the light trap being *Pales maculata* and *Tipula oleracea*. The former flies in May and June. *Pales flavescens* is to be found in June and July. A few scattered specimens of *Tipula paludosa* are captured in June and July, but the majority are found in August and September, with several late specimens in October. The early specimens captured probably represent a small first brood, the second brood in August and September being much more abundant. Evidence of two broods is shown to a certain extent also in *Tipula oleracea*. The first brood appears in May, June and July, the second in September. The second brood here is smaller than the first. The remaining three species, *Tipula obsoleta*, *T. marmorata* and *T. pagana* are found in October.

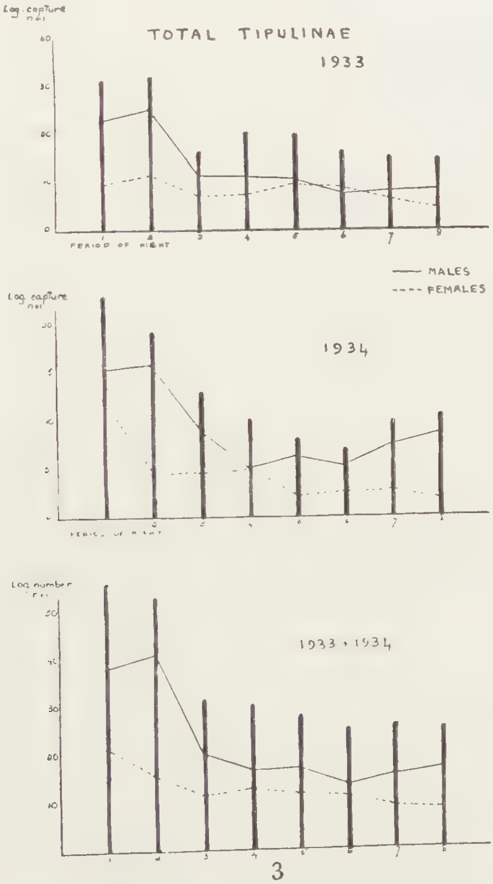

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Fig. 2 shows a graph of the sum of the logarithms of the numbers of all species of TIPULINAE captured each month during 1933 and 1934. The minor maximum in May is due to the presence of *Pales maculata*; the major peak in

September is due to large numbers of *Tipula paludosa*. The curve of the male Tipulids follows that of the total Tipulinae, but that of the females shows a slight increase in October over September due to the presence of numbers of *Tipula obsoleta* in which the female is captured in greater numbers.

Night Distribution.

Dr. Williams in a previous paper (*loc. cit.*) has described the light trap and the bottle changing mechanism whereby the night is divided into eight approximately equal parts. It is thus possible to discover the time during the night that a certain species is most active.

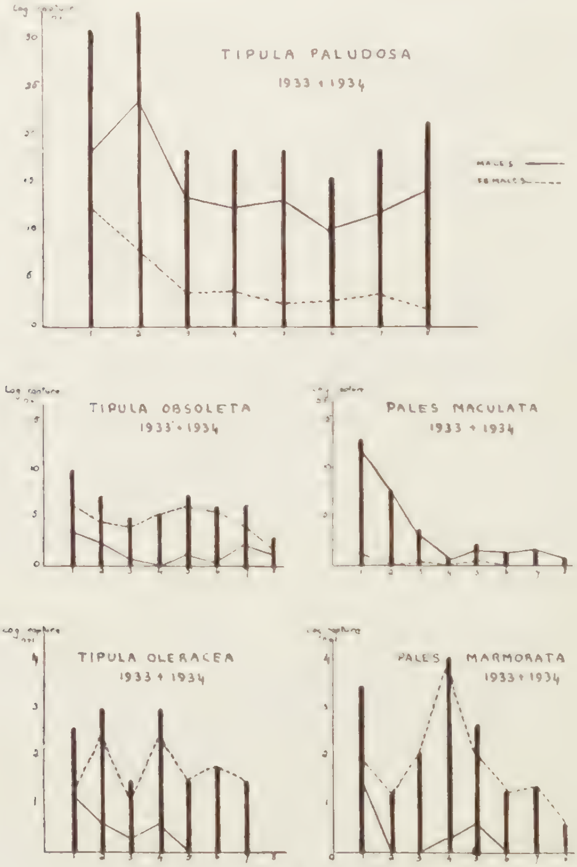

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Fig. 3 shows the distribution of the Tipulinae in the different periods of the night (sum of log $n + 1$). 1933 shows a maximum catch immediately after sunset, and another lesser peak at midnight, but the numbers decrease as dawn approaches. In 1934, although again there is a maximum at sunset, the numbers fall steadily throughout the night and begin to rise again towards dawn. The combined 1933 + 1934 diagram has eliminated the secondary maximum at midnight which appears in the 1933 diagram. The diagram shows a rapid decrease from sunset until about an hour before midnight, when the numbers remain steady throughout the night. Analysis of the separate sexes shows that the females decrease steadily from sunset until 11 p.m. and remain steady until before dawn, when their numbers decrease still further. The males, on the other hand, reach a maximum after sunset, then decrease, although they show a slight increased activity at sunrise.

Fig. 4 shows the distribution of certain species. A somewhat similar distribution to that of the total TIPULINAE is given by *Tipula paludosa* for 1933 + 1934. The total numbers here give a maximum immediately after sunset, decreasing during the night and increasing again at dawn. The distribution of the males alone is similar to this, but the females show a steady decrease from a maximum at sunset until just before midnight, and a further decrease before dawn. *Tipula obsoleta* also shows a decrease from a maximum at sunset, but is characterised by another increase immediately after midnight, the numbers then decreasing as sunrise approaches. In *Pales maculata*, the decrease from a maximum at sunset to a minimum at midnight is very marked. A small maximum immediately after midnight is followed by a slight decrease at dawn. In this species, there were very few females captured. In *Tipula oleracea*, where the number of females exceeds that of the males, the maximum at midnight equals that just after sunset, and there is a fairly steady decrease after midnight, reaching zero at daybreak. The male in this species shows an earlier activity than the female, contrary to the general rule. From a maximum at sunset, the numbers of the males decrease, but there is a small peak just at midnight, after which the numbers drop to zero, no males being caught in the early hours of the morning. A somewhat similar distribution of males is shown in *Pales marmorata*, the time of maximum activity being at sunset and just after midnight. The females again show an earlier activity in that the second peak occurs at midnight, about an hour earlier than the male maximum.

To sum up, it appears that for all species of TIPULINAE there is a maximum at sunset and the activity of the group then decreases, although there is, in all species save *Tipula paludosa*, evidence of an increased activity at or just after midnight. The activity usually decreases as dawn approaches, but here again *Tipula paludosa* is exceptional in showing an increase in numbers at daybreak. Further, it appears that, generally, the females reach a maximum slightly earlier than the males. Thus it is the general rule for the females to decrease in numbers from a maximum at sunset, while the males show a maximum in the period immediately after sunset. In the midnight activity, also, the females often show an earlier abundance. *Tipula oleracea* is the only exception to this earlier flight of females. Here the male reaches a maximum at sunset and the female after sunset, although the midnight maxima coincide.

Proportion of the Sexes.

The two year's catch taken as a whole indicates a general tendency on the part of the trap to attract a larger proportion of males than females. The yearly distribution of the sexes is given below :—

Total TIPULINAE.	Ratio ♂ : ♀.	Percentage ♂♂.
1933	833 : 422	66·4
1934	598 : 238	71·5
1933 + 1934 . . .	1431 : 660	68·4

The details for each species are as follows :—

Species.	1933.	1934.	Total.	% ♂.
A. ♂♂ in excess :—	♂, ♀.	♂, ♀.	♂, ♀.	
Pales maculata . . .	124; 9	86; 1	210; 5	97·7
Pales flavescens . . .	18; 2	26; 10	44; 12	78·6
Tipula paludosa . . .	578; 209	413; 92	991; 301	76·7
**Tipula pagana* . . .	63; —	33; —	96; —	—
B. ♀♀ in excess :—				
Tipula oleracea . . .	9; 42	5; 6	14; 48	22·6
Tipula obsoleta . . .	33; 126	29;109	62; 235	20·9
Tipula marmorata . .	4; 39	2; 20	6; 59	9·2

C. The small numbers of *T. luteipennis*, *T. vernales* and *T. fascipennis* captured were all males.

* ♀ wingless.

The above table shows that, although as a whole the males preponderate, in three species captured, viz. *Tipula oleracea*, *T. obsoleta* and *T. marmorata*, the percentage of males is lower than that of females. A preponderance of females over males is reported by Alexander (1919) who says of the TIPULIDAE "the great majority of photophilous species taken are either females, or males and females in copulation indicating a nocturnal or crepuscular habit for the species." It may be noted here that figures obtained for the LIMNOBIINAE and the TRICHOCERINAE captured in the light trap show that the females of these sub-families are far more numerous than the males. The preponderance of males over females for the total TIPULINAE is due to a few species of *Tipula* and *Pales* in which the males predominate. The presence of *Tipula pagana* increases the male ratio to a certain extent, since in this species the female is wingless and only the male is captured.

SUMMARY.

1. Crane-flies of the sub-family TIPULINAE which were captured in a light trap at Harpenden numbered 1256 in 1933 and 836 in 1934. Eleven species were represented. The number and percentage of the individual species is given, as well as their annual periods of flight.

2. A study of the distribution throughout the night of the total TIPULINAE shows that the maximum activity is reached at dusk, after which the activity falls to a constant figure about an hour before midnight. Analysis of the separate sexes give the maximum activity of females at dusk, where the males reach a maximum an hour later. There is usually a decrease in activity in both sexes at dawn. The night distribution of the most abundant species, *Tipula paludosa*, *T. obsoleta*, *Pales maculata*, and *P. marmorata* are analysed separately.

3. The proportion of the sexes shows that in general, twice as many males as females are captured. This is, however, due mainly to the very much greater ratio of males to females in one or two species, viz. *Tipula pagana* (all males, since female is wingless), *Pales maculata*, *P. flavescens* and *Tipula paludosa*.

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ON THE NOCTURNAL ACTIVITY OF TIPULINAE (DIPTERA) AS MEASURED BY A LIGHT TRAP

(2) THE INFLUENCE OF TEMPERATURE, CLOUD AND MOONLIGHT ON THE NUMBERS OF INSECTS CAPTURED

By R. D. PINCHIN, B.Sc., and JOAN ANDERSON, M.Sc.
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Communicated by Dr. C. B. WILLIAMS, F.R.E.S.

IN a previous paper (1936, *Proc. R. ent. Soc.* (A) **11 :** 69) an account was given of the numbers, species and sex proportion of TIPULINAE captured in a Light Trap at Rothamsted during 1933 and 1934, and of their periods of flight during the year and during the night.

This present note contains an account of a preliminary analysis of the figures to show the effect of maximum and minimum temperature and of cloud and moonlight on the captures.

(i) *Temperature.*

The number of the different species of TIPULINAE captured appears to be directly influenced by temperature. In the case of *Tipula paludosa*, which lends itself more particularly to statistical analysis since it appears in some numbers, a correlation between the log $(n + 1)$ of this species and the minimum temperature during the month of September gave a figure of $+ 0{\cdot}91$ in 1933, and $+ 0{\cdot}80$ in 1934. Both of these values are positively significant, the former being exceptionally high. A correlation between the log $(n + 1)$ of *Tipula paludosa* and the maximum temperature for September gave a low figure for 1933 $(+ 0{\cdot}23)$, but in 1934, the figure $(+ 0{\cdot}57)$ is significant. In neither year, however, did the correlation value approach that obtained for the minimum temperature, so that it would appear that the nightly minimum temperature is of greater importance than the maximum temperature in determining the activity of this species. The figures given above are obtained from a direct correlation between two factors :—

(i) The departure of the log $(n + 1)$ of *Tipula paludosa* for each night from a running 15-day mean, and

(ii) The departure of the minimum or maximum temperature from a similar 15-day mean.

There has been no correction made for any other factors (*e.g.* moonlight, cloud or humidity) which are known also to affect activity. Moreover, the above figures are for only one species, and for only one month of the year. Satisfactory correlation values cannot be obtained for the other species of TIPULINAE, owing to the small numbers captured, and to their short period of flight.

The method at present employed, then, of correlating the log $(n + 1)$ of the captures with the temperature does not give a true figure of the effect of temperature on the activity. However, a more satisfactory method of analysis is being investigated, which will give a figure expressing the effect of temperature alone, unmodified by the effect of other factors.

(ii) *Effect of Moon and Cloud on the Activity.*

The method used by Williams (in press) for showing the effect of moon and cloud on the activity of certain insects, consists in dividing the days in each of the six summer lunar months into nine categories according to whether they are in the nine combinations of

(1) (*a*) week of full moon, (*b*) intermediate weeks, (*c*) week of no moon;

(2) (*a*) less than 10% cloud, (*b*) from 10% to 90% cloud, (*c*) more than 90% cloud.

The numbers of insects captured on each night is first expressed as log $(n + 1)$, then a 29-day running mean is made of these logarithms, and finally each day is expressed as a departure of its logarithm from the running mean for that day.

This value is placed in one of the 9 categories, according to the moon and cloud conditions on that particular night, and finally an average logarithm departure is found for each of the nine categories. Since the mean logarithm of the whole series is known, each category can then be expressed as the logarithm, plus or minus the departure, and hence can be reconverted back into the numbers and percentages.

There is no need to go into the details of the working, but the results for the Tipulinae for the six lunar months in 1933 and 1934 are as follows:—

1933. (Log departures.)

	Clear.	Intermed.	Cloud.	
Full moon	− 0·12	− 0·14	+ 0·17	− 0·08
Intermed.	− 0·15	− 0·01	+ 0·24	+ 0·02
No moon	+ 0·12	+ 0·09	+ 0·26	+ 0·13
	− 0·09	− 0·02	+ 0·23	

1934.

	Clear.	Intermed.	Cloud.	
Full moon	− 0·23	+ 0·06	+ 0·17	− 0·05
Intermed.	− 0·01	+ 0·14	+ 0·03	+ 0·08
No moon	− 0·08	+ 0·13	+ 0·23	+ 0·08
	− 0·10	+ 0·13	+ 0·13	

1933 + 1934.

	Clear.	Intermed.	Cloud.	
Full moon	− 0·17	− 0·06	+ 0·17	− 0·07
Intermed.	− 0·09	+ 0·08	+ 0·17	+ 0·05
No moon	+ 0·01	+ 0·11	+ 0·24	+ 0·10
	− 0·09	+ 0·05	+ 0·19	

Since the mean logarithm $(n + 1)$ capture for 1933 + 1934 = + 0·55 then the actual logarithm for 1933 + 1934 for each category is as follows :—

1933 + 1934.

	Clear.	Intermed.	Cloud.	
Full moon	0·38	0·49	0·72	0·48
Intermed.	0·46	0·63	0·72	0·60
No moon	0·56	0·66	0·79	0·65
	0·46	0·60	0·74	

These logarithms, when reconverted to whole numbers and expressed as percentages, give the following :—

(a) *Actual numbers.*

	Clear.	Intermed.	Cloud.	
Full moon	1·4	2·1	4·2	2·0
Intermed.	1·9	3·3	4·2	3·0
No moon	2·6	3·6	5·2	3·5
	1·9	3·0	4·5	

(b) *Percentages* of mean.

	Clear.	Intermed.	Cloud.	
Full moon	54	81	162	77
Intermed.	73	127	162	116
No moon	100	139	200	135
	73	116	173	

These figures show, then, a steady increase in the numbers of total Tipulinae caught in the light trap from a minimum on clear nights in the week of full moon to a maximum on the cloudy nights, in the week of no moon. The intermediate figures shows that the steady rise in numbers is consistent throughout the series.

The above calculations have not taken into account the minimum temperature during the night. This is generally higher on cloudy nights, since in the presence of a cloud very much less heat is lost to the atmosphere by radiation. The following diagram gives the departures of the nightly minimum temperature from a running 31-day mean over the same periods for 1933 and 1934 as are used in the previous diagrams. Departures from a running monthly mean are taken in order to smooth out seasonal changes in temperature.

	Clear.	Intermed.	Cloudy.	
Full moon	− 0·31	− 0·22	+ 2·96	+ 0·80
Intermed.	− 2·09	− 0·11	+ 1·80	− 0·26
Full moon	− 1·42	− 0·85	+ 2·70	− 0·17
	− 1·48	− 0·16	+ 2·30	

This shows a consistent rise in temperature from the clear nights to the cloudy nights, and at the same time shows there is no correlation of minimum temperature with the full moon and no moon weeks.

In the previous diagram, therefore, the high numbers of total TIPULINAE on the cloudy nights is partly at least due to the higher minimum temperatures on those nights. The temperature factor does not, however, effect the numbers given for nights of full, intermediate and no moon. The conclusion can be drawn, then, that the numbers of TIPULINAE attracted to the light during 1933 and 1934 was appreciably greater on nights of no moon and less on nights of full moon in the proportion of about 135 to 77; and on cloudy nights to clear nights in the proportion of 173 to 73.

SUMMARY.

1. There is a high positive correlation between minimum temperature and the numbers of *Tipula paludosa* captured in September. Maximum temperature gives a much lower correlation value. The figures suggest that minimum temperature is an important factor in determining the activity of the species.

2. The numbers of TIPULINAE captured are greatest on nights in the no-moon week of the lunar month which have over 90% cloud, and are least on nights in the full-moon week which have under 10% cloud. Between the two extremes there is a steady gradation, depending on the moon and cloud conditions.

THE OCCURRENCE OF THE CHALCIDS *ENCARSIA PARTENOPEA* MASI AND *E. TRICOLOR* FÖRSTER IN ENGLAND (HYMENOPTERA)

By Colin G. Butler.

(*From the Entomological Department, Zoological Laboratory, Cambridge.*)

Communicated by Dr. A. D. Imms, F.R.S., F.R.E.S.

In September 1935 an extensive search was made in order to discover parasites of the Cabbage Whitefly, *Aleurodes brassicae* Walk. Large numbers of the pupae were collected within a thirty-mile radius of Cambridge, and allowed to emerge in separate batches, careful note being taken of the locality from which they were collected. In this way the vast majority of the material was found to be unparasitised, but, from three plots (in Cambridge) parasites were obtained. From one of these plots two species of Chalcids were reared, and Dr. C. H. Ferrière has identified these as being *Encarsia partenopea* Masi and *E. tricolor* Förster; from the other two plots only *E. partenopea* was obtained. The latter species Dr. Ferrière states is frequently placed in the genus *Trichaporus* Först.

Of these two species, large numbers of males but few females of *E. partenopea* were obtained, while many females and but few males of *E. tricolor* were reared.

Dr. Ferrière further remarks that he believes *E. tricolor* has not been previously recorded from Britain. This species is recorded by Mercet (1930) as a parasite of *A. brassicae* and of *A. proletella* and as occurring in Europe and Egypt. Boselli (1935) records *Prospaltella* (*Doloresia*) *coniugata* Masi which is, presumably, this species (as will be discussed later) as occurring in Italy as a parasite of *A. brassicae.*

There is also a record of a male and a female specimen of *E. tricolor* having been reared from a Coccid, *Aulacaspis rosae*, collected at Barcelona, but Mercet (1930) doubted the authenticity of the host. It is noteworthy in this connection that Mercet described in this same paper *E. indifferentis* as a new species from the Coccid *Chionaspis striata* Newst.

It is perhaps of interest to note that *E. tricolor* has been described at different times under several different generic and specific names. Originally Förster (1878) described it as *Encarsia tricolor*, but Masi (1908) described it as *Prospalta coniugata*; and in 1921 Mercet, presumably thinking it was a member of the genus *Doloresia*, recorded it under the name *Doloresia coniugata*, but in 1930 he recorded it as *Encarsia tricolor*. Further, Boselli (1928) in his record of the parasites of Italy, listed this species as *Prospaltella* (*Doloresia*) *coniugata* Masi, which is probably an error, *Prospalta* being the genus intended.

E. partenopea has been recorded as a parasite of the Pomegranate Whitefly, *Siphoninus granati* Pries. and Hosny, in Egypt by Priesner and Hosny (1932). These authors state that in some districts parasitisation may reach 80 per cent. or more; they also mention that it has been reared from *Siphoninus phyllyreae* (Hal.) in Italy.

I am indebted to Mr. E. R. Speyer for specimens of *E. partenopea* which he reared from the Greenhouse Whitefly, *Trialeurodes vaporariorum* West., collected in September 1926 at Wisley, Surrey. Speyer's specimens, which were identified by Mr. A. B. Gahan of Washington, D.C., are distinctly smaller than those reared from *A. brassicae*, this difference in size presumably being correlated with the difference in size of the host. From the few observations that I have made up to date, both these parasites seem to be capable of breeding parthenogenetically, and the egg seems to be deposited in a well-advanced pupa of *A. brassicae.* It is noteworthy that Speyer also found that a female *E. partenopea* had deposited an egg in a very well-advanced pupa of *Trialeurodes vaporariorum.*

The pupa of *A. brassicae*, when parasitised by *E. partenopea*, first of all turns yellow and later black, so that parasitised pupae are readily distinguishable from unparasitised ones. The parasite lies in the pupa case of its host with its head pointing towards the anterior end, but with the underside of its body directed to the dorsum of the host, which position must facilitate emergence from the host's pupal case, which is performed by means of the mandibles.

The following characters may prove useful in distinguishing between *E. partenopea* and *E. tricolor* :—

E. partenopea.

♂.	♀.
Head and abdomen black.	Black thorax and yellow abdomen, more or less darkened at the sides and at the extreme base.
	Antennae and legs, except the coxae which are shaded, yellow.
	Wings colourless with greyish veins.
No distinct club to the antenna which is 8-jointed.	Club of antenna 2-jointed.
	Antenna 8-jointed but shorter than that of male.

E. tricolor.

♂.	♀.
Brownish thorax with yellow scutellum which may be darkened but is never quite black as in *E. partenopea.*	Brownish thorax with yellow scutellum which may be darkened but is never quite as black as in *E. partenopea.*
Antenna 7-jointed.	Antenna 8-jointed.

It is hoped that those who have opportunities for rearing parasites from Aleurodidae, will record the species bred, in order that more may be known of the distribution of these Chalcids in Britain.

I should like to take this opportunity of thanking Dr. A. D. Imms, F.R.S., for his kind supervision and help with the compiling of this note.

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